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ECONOMIC GEOGRAPHY

APRIL

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S. Van Valkenburg

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Joseph A. Russell

RECREATIONAL LAND USE IN NEW ENGLAND
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SUGAR AND LAND USE IN THE BRITISH LESSER ANTILLES
Otis P. Starkey

LARK UNIVERSITY, WORCESTER, MASSACHUSETTS, U.S.A.

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Dr. Durand, of the University of Wisconsin, has recently been working on geographical problems in Wisconsin, and in the dairy regions of the United States. Two contributions to ECONOMIC GEOGRAPHY are the "Cheese Region of Southeastern Wisconsin" in the July 1939 number, and the "Dairy Region of Southeastern Wisconsin and Northeastern Illinois" in the October 1940 issue.

Mr. Kostanick, now working on his Doctorate at Clark University, shared with Mr. Prunty the field work necessary for the article which they contribute to this issue of the magazine.

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PART-TIME FARMING

PART-TIME farming, the system in which man devotes the major part of his time, or the greater part of his interest, to some manufacturing or professional vocation, and the time left free to farming, has developed chiefly since improved means of transportation have enabled him to live some distance from his regular work; since modern improvements in country living have made life away from city conveniences as comfortable and gracious as that in a metropolis; and since the telephone and daily country post have enabled the folk of separated rural homesteads to maintain as close communication and association as if they were adjacent neighbors. Most part-time farming forms an avocation, a means of recreation, rather than a commercial enterprise.

As technology advances, as mass production of material equipment increases, and as more goods can be produced within short time than can be marketed or consumed, the hours spent at furnace or roller or drill; at jenny or vat or loom; at machine or desk or counter; on truck or train or highway will be reduced, and man will find time to renew his acquaintance with his land, to till and sow and reap, to watch the seasons come and go, and finally to become a part of the world in which he lives. He will become a part-time farmer.

The richest gain that will accrue to man from this part-time farming will be not the food that he produces, fresh and nutritious as it may be, but the better health that it yields, the wholesome concept of life and life's activities that it affords, and the more coöperative attitude toward his fellows that it imposes. He and his family will achieve from the farm a unity of purpose, a community of interest, an integrity of family character that they could not possibly achieve without the chance to work together in spading a cabbage patch, raking a seed-bed, planting strawberries, digging potatoes, gathering eggs, milking cows, or doing the hundred and one other little duties that part-time farming prescribes. Content and health and happiness will follow in the wake of wider development of part-time farming.

ECONOMIC GEOGRAPHY

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STRUCTURE OF ITALIAN AGRICULTURE

S. Van Valkenburg

ONE of the most important projects considered at the International Geographical Congress at Amsterdam in 1938 was the evaluation, by means of numerical indices, of the productive value of soil and climate in some way more exact and accurate than any previously devised, in order to obtain a measure of economic comparison between various countries.

Dr. Ellsworth Huntington offered an answer to that question in a paper which he entitled, "The Productivity of the Soil: A Preliminary Investigation of the Relative Value of Field Crops Per Hectare Throughout the World." At the same time he presented another report on his investigations: "Agricultural Productivity and Pressure of Population," which appeared in the Annals of the American Academy of Political and Social Science, July, 1938.

As Huntington indicated, his study was only preliminary; at his suggestion the author has continued the research and carried it far beyond the preliminary stage. While the survey covers all Europe and eventually, it is hoped, will be published in later articles, this discussion which concerns only Italy and must be regarded as a type study, explains procedure for the proposed method and the results that accrue from its use.

Italy was selected because it is one of the few European countries with complete provincial statistics and because it offers great geographical diversity consequent upon its variety of relief and climate, under one political order. However, this article is not intended to explore and explain details of Italian agriculture nor are the many maps to be used for exhaustive explanation. Such intensive study would have proved interesting, but it would have distracted attention from the chief purpose of the article—to show effectiveness of the method in a study of land utilization.

METHOD

The Huntington method of index numbers representing values is rather simple. An index of 100 is established upon the world price of a unit of weight (in this study a quintal was used) containing equal quantities of wheat, barley, and corn, chosen as the elements of the base index because of their wide distribution and world price quotation. Every other crop is then evaluated in its price relation to the base index. To obtain such relations, world prices if possible, and otherwise prices quoted by individual countries, are ascertained for a long period of years, resulting in a long list of world price relations, which,

STRUCTURE OF ITALIAN AGRICULTURE EXPRESSED IN VALUE INDICES

(000,000 omitted) for units of 1 million hectares

Value Index	*Crop Unit*	*Piemonte*	*Lombardia*	*Veneto*	*Veneto Tridentina*	*Veneto Giulia*	*Emilia*	*Liguria*
Multiplier		*1.18*	*1.39*	*1.18*	*10.60*	*7.76*	*1.20*	*8.10*
123	Wheat	862	1,266	931	340	329	1,575	262
91	Rye	68	35	4	178	23	...	...
87	Barley	2	...	3	54	37	138	...
92	Oats	36	38	13	26	23	174	...
88	Corn	380	852	768	236	285	249	108
107	Rice	410	387	35	...	...	51	...
	Fiber							
a. 826	a. cotton							
b. 413	b. hemp	...	...	31	...	...	157	...
c. 593	c. flax							
680	Tobacco	...	12	...	...	...	...	...
22	Sugarbeets	9	38	290	...	...	224	...
42	Potatoes	31	120	97	657	584	75	320
175	Dried Beans	90	21	43	133	249	40	39
50	Wine Grapes	332	220	218	400	278	365	391
139	Olives	...	6	5	...	73	7	795
300	Asparagus	6	3	4	...	...	...	44
300	Artichokes	...	...	4	...	...	5	110
50	Thistles	3	3	...	...	...	2	41
49	Cabbage	18	27	25	90	67	2	99
100	Cauliflower	2	3	7	...	...	5	31
68	Onions	40	9	7	...	...	20	9
200	Beans and Peas (fresh)	4	18	21	...	...	33	511
57	Tomatoes	3	20	9	...	62	161	227
50	Melons	10	30	34	...	17	50	...
40	Apples and Pears	48	12	8	402	25	23	25
172	Peaches	44	22	123	42	37	100	843
279	Cherries	23	9	13	32	72	31	35
120	Table Grapes	25	22	7	30	39	23	61
356	Nuts	34	23	...	17	...	15	40
130	Oranges	...	...	...	...	...	...	...
191	Lemons	...	...	...	...	...	...	...
140	Limes	...	...	...	...	...	...	...
180	Tangerines	...	...	...	...	...	...	...
100	Figs	...	...	...	...	...	...	...
80	Carobs	...	...	...	...	...	...	...
	Total	2,580	3,196	2,710	2,637	2,199	3,525	3,991

of course, may deviate in certain cases considerably from the local conditions. The list of index values has been published by Huntington and later enlarged by the author, with only one important change made, namely a substantial reduction in the value of potatoes, for which the former figure did not express European conditions. In the table included, value indices are shown in the first column for all crops used in Italy. If so desired, the index numbers may be changed into actual money by using the price of a mixture of wheat, barley, and corn, instead of the index of 100.

The method has the outstanding advantage that by its use, productive value of countries can be evaluated and production of various crops compared in equal terms. In popular form, spinach can be compared with wheat and tobacco by this method because they are all expressed in the same system of value indices. It is necessary, however, to emphasize distinct limitations of the method and caution against its use for other purposes than for which it is intended.

As has been stated, the indices are based on world prices and do not represent local values. Crops, for which no international market prices existed, are valued in national prices and the final index value fixed as the average of the various relations of the value of that crop to the base value of wheat, barley,

STRUCTURE OF ITALIAN AGRICULTURE EXPRESSED IN VALUE INDICES—*Continued*

(000,000 omitted) for units of 1 million hectares

Toscana	*Marche*	*Umbria*	*Lazio*	*Abruzzi e Molise*	*Campania*	*Puglie*	*Lucania*	*Calabrie*	*Sicilia*	*Sardegna*
1.16	*2.46*	*3.57*	*1.46*	*1.24*	*1.30*	*0.81*	*2.74*	*1.67*	*0.62*	*2.37*
711	1,306	1,026	500	626	449	459	739	504	770	558
8	...	...	...	...	9	...	...	...	...	...
9	12	15	...	...	6	36	30	13	32	62
52	...	30	38	20	30	109	168	66	25	35
124	166	104	140	130	168	10	58	86	...	16
...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	120	...	...	...	21	...
...	...	...	...	...	68	68	...	...	...	...
20	5	20	11	27	...	...	...	...	...	...
79	117	95	49	154	231	14	42	86	9	22
178	54	80	105	119	93	48	198	96	270	180
343	350	298	193	137	343	259	71	89	149	73
151	51	171	181	132	160	431	175	389	136	100
...	...	...	...	...	...	...	...	...	...	...
20	...	...	57	...	33	6	...	...	30	77
2	9	...	23	4	10	5	...	...	15	...
4	5	...	24	5	16	5	81	24	5	3
44	35	14	27	6	109	5	...	8	25	...
4	...	...	59	11	14	2	3	7	12	...
26	27	...	34	...	52	26	9	6	38	27
34	40	19	31	27	112	21	11	30	39	22
11	6	5	11	7	46	17	...	11	6	13
9	20	7	9	24	39	5	7	26	9	5
23	17	12	15	9	15	7	...	13	11	10
...	...	...	8	18	46	13	10	18	...	8
23	12	31	23	8	43	16	...	4	17	11
8	...	...	21	54	171	194	16	29	200	95
...	...	...	21	...	62	8	8	148	147	13
...	...	...	...	...	27	...	...	45	413	...
...	...	...	...	...	...	...	...	12	...	...
...	...	...	...	...	18	...	...	...	35	...
...	...	...	...	...	12	27	...	26	...	...
...	...	...	...	...	...	...	...	...	20	...
1,882	2,232	1,927	1,581	1,518	2,602	1,791	1,626	1,736	2,434	1,330

and corn. In such cases wide deviations may develop locally for the chosen index. For instance, the price of cauliflower in the Netherlands will not be identical with the price of that same vegetable in Naples; and the price in spring in Naples, when cauliflower moves northward as a spring vegetable, will be much higher than the price later in the year based on local demand. A great deal of difficulty is eliminated, however, because the index refers to price relation, not to actual price of the crop concerned.

Aside from distance to market and trade demand, the factor of quality has to be considered. Fruit varies a great deal because of quality difference: apples, for instance, will vary in price quotation; grapes for wine purposes even more. Some adjustments have been made, i.e., different indexes for table apples and cider apples; but not all the trouble can be overcome. Moreover, national policies, which interfere with the free flow of products, also interfere with natural price level, for prices can be artificially raised or lowered. The method is based on a unified European continent and not on one of tariff protected small units, which disrupt geographical conditions.

All these complications may worry the reader as it worried the author while working on the project. If proper use is made of the method however,

its advantages far outweigh any difficulties. In reality local deviations from price index are generally rather insignificant. In a few countries it was possible to compile a local price list and the outstanding result was close correlation between local figures and standard index values.

PHYSICAL BACKGROUND

Figure 1 gives the territorial units (provinces) used as base for the statistics to follow. A brief description of the physical setting follows.

Piemonte, Lombardia, Veneto, and Emilia, the four provinces of the Po Basin, a very flat plain, extend into the surrounding mountains (Alps for the first three, Apennines for Emilia). A belt of hills rises between the plain and the mountains in many places; in Piemonte that belt widens and occupies most of the area south of Torino.

Veneto Tridentina is entirely a mountain province. Its chief agricultural asset is the Adige Valley system, especially the Merano section west of Bolsano. Veneto Giulia contains the Carzo Plateau (the famous limestone region of distinctive topography) as well as the Istrian Adriatic coast.

Southward along the peninsula, the Apennines shift towards the Adriatic side and the two provinces on that side (Marche and Abruzzi) include chiefly a narrow coastal plain and the eastern mountain slopes. In Italy the terrain in its agricultural prospects does not correspond to contour lines and definite elevation. Sharp forms can appear in otherwise level land, while higher sections can be rolling and prepared for cultivation. Thus it is difficult to make general statements, although of course in most cases high mountain sections are unfavorable for agriculture.

The provinces on the inner (western) side of the Apennine curve—Tuscany,

FIGURE 1.—Italian provinces are not so unequal in area that they offer serious problems in a comparative study in the structure of agriculture. Nevertheless there is considerable spread between Liguria, the smallest, and Sicilia, the largest, in areal extent.

Umbria, Lazio, and most of Campania—have complex topography in which rolling hills and in places steep escarpments of mountain blocks separate broad valleys and basins. Volcanic action, expressed in various forms ranging from old dykes and crater lakes to active volcanoes, favorably affects soil fertility. The Arno, the Tevere (Tiber), and the Lici are the chief river systems. The coastal plain changes width; in many places it is handicapped for agriculture by lack of drainage (i.e., the well known Maremma). However, such land is being reclaimed. South of Abruzzi, the Apennines curve back toward the Tyrrhenian Sea and occupy in Lucania and Calabria almost the entire width of the peninsula with only narrow coast plains on the sides. Puglie, chiefly a limestone plateau bordered by a relatively wide coastal plain, is outside the Apennine system.

Sicily has the Apennine backbone in the north—with Etna as a mountain

spur to the southeast; the rest of the island is a plateau which dips toward the south. Its coastal plains are narrow except for the plain of Catania south of Etna. Sardinia displays the complexity of old mountain topography, extensive plateaus, steep isolated mountain block, volcanic cones and lava flows, with relatively little lowland except for a wide depression which separates the main mountains from smaller uplands southwestward.

From the climatic point of view, Italy offers two distinct types, the Mediterranean and the Po Basin. The Po Basin type is one of cool winters with frequent frost periods, warm summers, and precipitation throughout the year, with a maximum in spring and fall. The basin shape causes cold winter air to flow toward the center, leaving the surrounding slopes considerably warmer. The Mediterranean type is

FIGURE 3.—Wheat, expressed in percentage of total values of food and industrial crops varies between 58 per cent in cereal Marche, where wheat exceeds the total of all other crops, and horticultural Liguria, where wheat is only a minor factor in agricultural production.

FIGURE 2.—Relative importance of wheat production varies between Emilia, the wheat province *par excellence*, and the mountain province, Veneto Tridentina, where conditions for growing of wheat are effectively unfavorable.

well known—mild rainy winters during which only a few cold spells interrupt the growing season and hot, dry summers. The boundary between the two climates can be defined as the crest of the Apennines from the French frontier almost in a straight line towards the Adriatic. The northern provinces of the Mediterranean zone, however, show transitional characteristics, especially is the dry season shorter and less pronounced. Besides the contrast from south to north, there are differences due to elevation. The Alpine zone to the north and the Apennine backbone of the peninsula have lower temperatures and more precipitation, with much snow in winter. However, they also conform to characteristics of surrounding coastal climates and while the Alps remain green in summer, the Apennines show effects of the drought of that period.

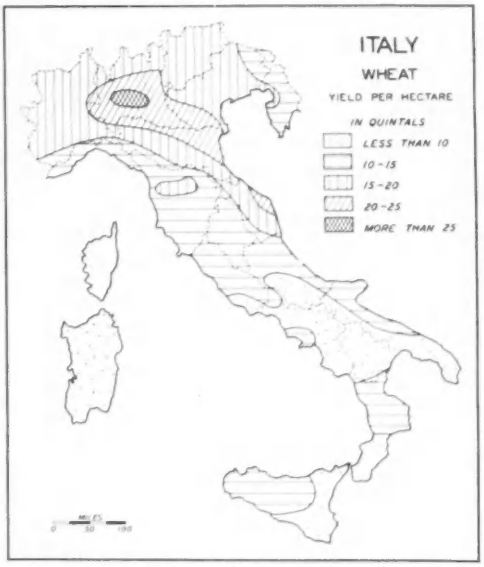


FIGURE 4.—Yields of wheat generally decline southward chiefly as a result of climate, but also because the soils are generally more productive in the Po Basin provinces than farther south.

USE OF THE METHOD

A. *On a Single Crop.* Wheat, Italy's major crop, is used here as an example to show how the value system can be applied to study distribution and intensity of production of individual crops.

Figure 2 indicates value of wheat expressed in value indices, per unit of one million hectares. The center of production is clearly in the Po Basin, Emilia having the highest value for Italy. The other three Po provinces have lower values—although still far above the Italian average (796)—because other crops (corn and rice) also rank high. The zone of great wheat intensity extends southwards along the Adriatic, including Marche and also the centrally located province of Umbria. In the northern mountain provinces, wheat loses much of its significance, and in Liguria, Italy's center of horticulture, the lowest level value of wheat is achieved. On the rest of the peninsula wheat value indices vary between 770 and 449, high where wheat is practically the only important crop, low where other crops come to the foreground, especially true for Campania (horticulture) and Puglie (olives).

The next wheat map (Figure 3) shows percentage of the total value of all food and industrial crops occupied by wheat. The Italian average is about 35 per cent and in many provinces the wheat percentage deviates only slightly from the average. High plus values appear variably in the zone on the north foot of the Apennines (Emilia and Marche) and in Umbria, while in the south, Lucania attains the astonishingly high figure of 62 per cent, indicating that wheat covers about two-thirds of the whole food crop value. Low again are percentages for the northern mountain provinces and the horticultural sections of Liguria and Campania. Puglie with its olives is also comparatively low.

Interesting for comparison is the map of yield of wheat (Figure 4) expressed in quintals per hectare (by the way, this map is not based on value indices). The center of the Po Basin (Lombardia) shows yields more than 2½ times those of Lucania, while the percentage of wheat, in value, is much higher in the second province. From the Po Basin yields generally decline southwards, while yields in the northern mountain frame are also lower. It is clearly indicated that although wheat is undoubtedly the cereal crop of the Mediterranean, its yields are lower under climatic conditions typical for the region; but it is essential to point out that although yields in the central Po Basin are high, they do not present the European maximum found in countries around the North Sea.

The next map (Figure 5) of the wheat series presents actual value indices for wheat, now not per unit of one million

FIGURE 5.—The absolute importance of wheat production shows how the provinces of the Po Basin as well as Marche and Umbria produce most of the wheat crop of Italy.

hectares but per actual land occupied by wheat. As provincial acreages occupied by food and industrial crops fall generally below the one million hectare (except for Puglie and Sicily), the actual figures are below, often far below, those of Figure 2. Wheat values in the northern mountain province and in Liguria are on this basis almost negligible. The Po Basin is still important, with Emilia the leading province. However, in the south, Sicily appears as an important wheat producer. Interesting to note is how Lucania with highest wheat percentage is low in production because of small yields and low proportion of cultivated land.

The figure can be used as base for a value dot map (Figure 6). In the placing of the dots, however, personal knowledge as well as study of physiography bases has been used to make the map as accurate as the large provincial units permit. Similar dot maps can be made for other crops and in each case the dot has the same value and the maps are directly comparable. Herein lies one of the major assets of the system.

The preceding wheat maps have served principally as example of what can be done for each crop. Space prevents more examples, but for the geographer they should be extremely interesting as they force him to seek reasons explaining differences. The maps are not final; but they present problems which must be solved.

B. *On the Value of Italian Agriculture.* Agricultural intensity is expressed by Figure 7 which gives the index value per unit of one million hectares for every province. The unit seems rather large as only in the cases of Sicilia and Puglie is the actual acreage above that figure. On the table is given for each province the figure used with which to multiply the actual amount in order to bring it up or down to one million

FIGURE 6.—The distribution of dots, representing wheat values, is based on intimate personal knowledge of terrain within the provincial boundaries. Similar maps based on statistics alone have little local value if territorial units are large.

FIGURE 7.—Relative values of food and industrial crops indicate the high level of agricultural production of Liguria (horticulture) compared to their low value on Sardinia.

hectares. In some cases actual acreage is very low—in Veneto Tridentina less than 100,000 hectares. However, the one million unit has been used in the survey of all European countries and it was thought advisable to use the same unit in this particular study.

Though figures obtained are very interesting, they cannot be understood without employing the complete agricultural structure as given in the table and as discussed later in this article. However, some general observations can be made. That values vary between 3991, Liguria, and 1330, Sardinia, a relation of 3 to 1, indicates that raising of crops is three times as extensive in Liguria as in Sardinia. The value in the Po Basin is high as also in the northern mountain province (Veneto Tridentina), showing a high level of land use as far as crops are concerned. The excellent climate of the Merano Basin is one of the reasons which helps explain that level. The Istrian Upland has much lower intensity but is still well above most peninsular provinces. The figure combines the horticultural coastal plain and the less productive upland plateau. Values on the peninsula are rather uniform—generally between 1900 and 1600; Marche still shows the influence of the Po Basin intensity of which it is the direct continuation. Campania and Sicily are (as will be discussed later) mixed types in which horticulture is responsible for the higher values. Sardinia is very low, partly through physical disadvantages but also because of centuries of neglect.

Another way of expressing intensity is used in Figure 8, which indicates the deviation from the Italian average, expressed in percentage of the average. Sardinia has 57 per cent; Liguria 170 per cent; again, of course, the relation of 1 to 3.

FIGURE 8.—Northern Italy as well as horticultural Campania and Sicily is above the Italian average of value of agricultural production. Sardinia on the other hand falls far below that level, the lowest of all.

However, figures expressed in value indices of one million hectares have only comparative value because actual figures of production are in most cases very much smaller. On the table is indicated relation between actual acreage and the one million unit (leading multiplier). From that relation it is easy to derive actual value indices for the various provinces (Figure 9).

Great differences exist between this map and the two preceding ones. Liguria, for instance, the peak province in intensity, is one of the lowest in actual value, the result of small acreage. The mountain provinces are only minor factors in Italy's food supply. The Po Basin provinces remain relatively high as acreages approach one million hectares, but Sicily is now highest because of the large acreage in crops. Besides Sicily, Puglie is the only other province where the actual figure is higher than the comparative. In actual value Umbria is even lower than Sardinia, while Lucania also approaches the lowest values. It would be tempting to make another dot map based on such actual figures, but a great deal of intimate local knowledge must be applied, for value density varies considerably within the provinces.

FIGURE 9.—Absolute values for agricultural production (food and industrial crops) obviously favor the larger provinces. Sicilia ranks first, Veneto Tridentina with its mountains, last. Liguria at the head of the list in a relative way, is one of the lowest from the point of view of absolute values, result of the small amount of land in cultivation.

FIGURE 10.—Percentages of land in crops (food and industrial) vary between 7 for Veneto Tridentina and 62 for Sicily. Figures for the Po Basin are rather low, because of the importance there of dairy, not included on the map.

The difference between value of the theoretical one million units and real values is due not only to difference in size of the provinces but also in percentage of the land in food and industrial crops (Figure 10). As can be expected, mountain provinces in the north show very low percentages; also the slope province, Liguria, has only one-fifth in those crops. The figure for Sardinia indicates that only a small part of the island is cultivated.

However, the map reveals the fact—for the moment puzzling—that the crop

land percentages generally increase from north to south, except for the provinces of Lucania and Calabria which contain much mountain topography. The solution to this seeming puzzle is given in Figure 11 which also states percentages but includes the area occupied by forage crops, improved pastures and meadows (prati). The percentage figures of the southern provinces alter only slightly; in the case of Sardinia as little as ½ per cent, while those in the north increase considerably and in one case (the Alpine province of Veneto Tridentina) more than double. Only Liguria remains low, while Marche, on the transition between south and north, has the highest percentage (76 per cent).

It is difficult to indicate the productive value of fodder crops and improved pasture by value indices, as their production has to be expressed in meat and milk and not so much in turnips and hay. While many European countries have complete statistics on meat, milk, chickens, etc., which will be used in a later study, they are not available for Italian provinces, and so it was impossible to give an exact figure for the value of stock raising.

FIGURE 11.—All crops, including hay and fodder, are taken into consideration in the map. Marche is now first. The Po Basin provinces rank high in contrast to the low places for Sardinia and Veneto Tridentina.

FIGURE 12.—Estimated value of total agricultural production supports the presumption that the four Po Basin provinces represent the most important part of Italian agriculture. Sicily also ranks high despite the fact that its land has been in use since the ancient period of glory in the Greek city states.

However, in order to derive an approximate idea of the total value of Italian agriculture an estimate is made in Figure 12 based on the supposition that value of fodder and improved pasture, evaluated as milk and meat, are about equal to provincial value of average food and industrial crops expressed in the same areal unit. This, of course, is a bold guess and should be regarded solely as such. However, the map portrays a correct picture generally. As may be expected northern values increase substantially, while those of the south neither rise nor fall. Figure 13, which gives the value per hectare

FIGURE 13.—Agricultural values per provincial hectare, vary between Emilia, the southern Po Basin province, representing the top, and poor Sardinia, again occupying the bottom.

of territory (of course, again the same remarks made concerning Figure 12 are true here) expresses it more satisfactorily. Emilia as the most valuable province from the agricultural point of view is conspicuous, with Lombardia second, and Marche third. Surprisingly, Sicily is fourth, slightly above Veneto. All through the study the author was impressed by Sicily's high value; it certainly reflects no credit upon Italy that this section has remained poor, and that profits escape the island to absentee landlords, while the peasants themselves who produce them share but slightly, or not at all.

Low in the scale, from the point of view of territorial value, fall the mountain provinces. Sardinia, where the value per territorial unit is only one-ninth of that of Emilia, sinks to the bottommost level.

But once more it is necessary to warn against too definite conclusions. Combined food and industrial crops, fodder, and improved pasture do not include all the productive land, for the forests, of which some have considerable value (although not expressible in indices) are omitted. For instance, to the disappointment of the author, chestnuts, for which Italy is famous, are given under forest acreage and not separately, so that they cannot be included, however, without seriously modifying the general result; unimproved pastures form another type of land use omitted which in mountain sections reach a high percentage as summer grazing for cattle and sheep. In northern mountain provinces the percentage of land in such pasture is 23 per cent for Veneto Tridentina and 17 per cent for Veneto Giulia. While figures for the Po Basin are generally low (Emilia, 4 per cent), Piemonte has as high as 13 per cent, also the percentage for most of the peninsula. Only Lucania is much higher (28 per cent), while Sardinia registered

FIGURE 14.—Sardinia finally takes first rank with its high percentage of unimproved pasture, a clear indication that little is done to improve its agricultural conditions.

FIGURE 15.—Agricultural types are here limited by provincial boundaries which naturally do not include the true regional areas. Nevertheless the structural base for the divisions is clearly shown on the accompanying statistical table.

29 per cent, which, of course, in reality should increase somewhat the final value expressed in Figure 14, although most such pastures are rather unproductive.

C. *Agricultural Structure.* The composition of provincial agriculture as indicated in the table represents the chief value of this method of using value indices. It is important to give an example to show how the figures are obtained. Taking the second item, rye, and the first province, Piemonte to illustrate, the figure 68 is obtained in the following way: The average rye production is taken for the last 7 years and multiplied with the wheat index. Then, because the total food and industrial crop acreage (average) of Piemonte is only 861,700 hectares, the figure obtained, representing the actual value, is multiplied by 1.18 in order to represent the base acreage of one million hectares, the result being 68,000,000, of which the millions are omitted in the list.

The real value of each crop can consequently be obtained by dividing by the figure called multiplier on the table, which was used to bring the actual provincial acreage up or down to one million hectares, the base used for comparisons. For example, the extraordinarily high figure for olives for Liguria (795) is in reality only 98 (divided by 8.1), while the much lower figure of 431 of Puglie in reality is 531 (divided by 0.812), more than five times that of Liguria.

The table on the structure of Italian agriculture can be employed to divide Italy into agricultural regions. Four main regional types (see Figure 15) stand out clearly with transitional zones between them. Because the survey is based on provinces, provincial boundaries must be used. With smaller divisions and with use of physiography, much better regional boundaries could be made. However, the types as such would remain. The four are the Po Basin type, the northern mountain type, the Mediterranean type (non-horticultural) and the horticultural Mediterranean type. The latter two might be called the irrigated and the non-irrigated Mediterranean type. Although irrigation plays an important part in the horticultural division, not all fruits and vegetables are irrigated.

Full appreciation of the following descriptions requires constant reference to the preceding maps, even though attention will not be called to them throughout the text.

I. *The Po Basin.* As one of the prominent types of European agriculture, the Po Basin merits rather full description.

Percentage of land in food crops varies between 30 and 40, which seems rather low, but if fodder and improved grassland are included, the percentage rises perceptibly and ranges from 55

to 64 per cent. Though the whole flat plain itself is productive and seen from the air displays a striking picture of parcelling (cities, villages, roads, etc., occupy a certain non-productive share), the enveloping mountains included within statistics for the provincial area account for the fact that the cultivated percentages are not higher; as forests and mountain pastures are not included as cultivated land and the higher mountain zone is entirely unproductive. Crop value indices are consistently high; highest in Emilia where the rolling slopes of the Apennines can be partly put in cultivation, lowest in Piemonte where hills and mountains occupy a considerable area. Yields are high as indicated by the wheat yield map; other crops would be similarly high. Cereals dominate the agricultural structure and in Lombardia attain 80 per cent of the total food and industrial crop value (see Figure 16). Differences in cereal proportions can be used for sub-divisions of the agricultural structure, although wheat in every case is the chief crop. Piemonte and Lombardia are the two rice provinces of Italy, where water from the Alps can be used for irrigation. Corn, also comparatively a wet ground crop, reaches its peak in Lombardia and Veneto. The isopleth map of corn (Figure 17) reveals the importance of the northern part of the Po Basin where summer rainfall is heavier but irrigation also is possible. In Emilia, the bread basket of Italy, wheat reaches its highest importance—almost half the total agricultural value is represented by wheat. Wine is prominent, especially in the Piemonte where the Asti region, south of Torinto, has a high reputation. Vegetables play a minor rôle, while of fruits, peaches thrive well in Piemonte and Emilia. Two industrial crops become primary—sugarbeets for Veneto and Emilia (Po Delta) and hemp (Emilia). The cold winter of the region prohibits the growth of olives, the great Mediterranean crop, while citrus fruits are limited to some well protected gardens along the Italian lakes.

FIGURE 16.—Cereals dominate Italian crop agriculture; even so the high figure of 80 for Lombardia is distinctly impressive. In Liguria cereals are subordinate to horticultural crops.

Although not included in the table, stock raising, based on fodder crops and irrigated meadows, is well developed here and constitutes the center of distribution of Italian cows (Figure 18) from which come the famous Parma cheese, as well as milk, butter, and meat. Altogether, the results obtained by this survey certainly justify the conclusion here that land utilization reaches not only the highest level in Italy but also a high ranking position in the whole of Europe.

II. A. *The Northern Mountain Type.* Veneto Tridentina represents the northern mountain type. As expected the area in food crops is limited, direct result of rugged terrain and high eleva-

FIGURE 17.—From statistical data of the various provinces, and by personal acquaintance with the terrain, isopleths could be made. Those of corn show the nucleus in the central part of the Po Basin and a sudden drop southward, the result of dry summers of the Mediterranean climate.

tion. The standard of agriculture is comparatively high but the actual figures are low. Wheat drops to almost one-fourth of its importance in Lombardia; also corn, while rye comes to the foreground, replacing wheat on mountain fields. Grapes are still important—the wines of the Merano Basin are well known. However, the most interesting fact is the high value of potatoes, by far the major crop of this type in value. Cabbage is the common vegetable. Conspicuous in this type also are pears and apples. Improved pasture occupies more acreage than food crops, and dairying is well developed. Altogether mountain agriculture is typical for most of the Alpine area and closely resembles that of Switzerland.

II. B. *The Sub-type of Veneto Giulia e Zara.* This type differs from the preceding type in two respects. First, Istria is a limestone plateau, not a high mountain range with deeply eroded valleys; second, a coastal zone is included with typical Mediterranean climate reflected in the olives, tomatoes, peaches, and more grapes than would otherwise be typical. However, upland character prevails and justifies its inclusion in the second type. High value of the potato crop and lower value percentage of wheat and corn emphasize the relation. Different, however, is unimportance of rye as well as of apples and pears; the Carzo Plateau with its raw climate is not a fruit region. Typical for the sub-type, is increasing importance of dried beans (Vicia alba). The total value of food crop per unit remains considerably below that of Veneto Tridentina. Though cattle are significant, sheep come more to the foreground than either in the Alps or the Po Basin, although not nearly so conspicuously as in peninsular Italy (Figure 19).

III. *The Horticultural Mediterranean Type.* The highest grade of land use of the Mediterranean climate—fields of vegetables, orchards of peaches, gardens of lemons and oranges with grapevines swinging from tree to tree or hanging from trellises—forms this type. However, its eminence is not possible without water running through narrow ditches to offset the scorching desiccation of the summer, although in certain places soils are moisture retentive enough to keep them productive through the summer heat.

Liguria is the best example. The south slope of the Apennines—a climatic oasis in winter as result of protection against inflow of cold northern air—is a garden of fruits and vegetables, not only for Italy but also for the general European market, where such subtropical fruits and early vegetables are in great demand. Agricultural intensity is the highest in Italy but cultivated

FIGURE 18.—The Po Basin with its flood plain meadows favors taurine cattle, but provinces of the peninsula proper where summers are dry present low figures for that type of livestock.

land is restricted to the immediate coast and some short valleys; the actual value is small. Very little land is in fodder or improved pasture. Even wheat, the crop which leads in all other Mediterranean provinces, achieves only sixth rank. Extraordinarily high value indices are obtained for olives, peaches, and grapes, although 90 per cent of the value is in fruits and vegetables, a unique case for the world. Again it must be indicated that actual figures are very much smaller and that the 843 index for peaches in Liguria is only slightly higher in actual amount than the 100 index for Emilia, while the actual olive figure is only one-fifth of that of Puglie. Of the vegetables, potatoes (especially early varieties), fresh peas, beans, artichokes, tomatoes, and cauliflower are most important. The Mediterranean region here attains its most perfect development, with nature exhausting itself in beauty.

Two other provinces in Italy show similar development. However, the type is less distinctive because of extension of the area far beyond the horticultural zone, with the result a mixed type in which the horticultural factor carries total value far above that of the surrounding non-horticultural provinces.

From the horticultural point of view, Campania differs from Liguria rather obviously. They have in common a general structure; though potatoes rank high and all kinds of fruits and vegetables are well represented, its lower latitude is reflected by appearance of oranges and lemons, while nuts also become important. Two industrial crops also should be noted: tobacco and hemp (Campania is the second producer after Emilia).

Sicilia differs from the other two. Its structure would even be typically non-horticultural Mediterranean with wheat, wine grapes, olives, nuts, and dried beans but for the fact that it forms the center of citrus fruit production, particularly of lemons of which the gardens dot the northern coastal zone of the island and which are chiefly responsible for the high value index.

IV. *Non-Horticultural Mediterranean Type.* Preëmpting the largest territory of Italy, this type is probably most characteristically developed in Lucania, where five crops comprise more than 80 per cent of the total value, namely wheat—only slightly less than 50 per cent, oats—often planted after wheat—dried beans, olives, and grapes. In Lucania grapes do not rank very high and fall below the general Mediterranean average, but otherwise represent the type.

Generally speaking, the percentage of land in crops is rather high, reaching 67 per cent in Puglie, with an exception in the toe province, Calabrie, where mountains prevail. Very little of the land is in fodder or improved pasture,

FIGURE 19.—Sheep, compared with cattle, reveal opposite distribution, for they thrive in areas of Mediterranean climate. Centers of sheep raising are on Sardinia, and about Rome on the Campagna Romana.

and sheep (Figure 19) replace cattle as typical stock; the valley of the Tevere in Lazio and the isle of Sardegna as a whole represent the peak of sheep density. Vegetables and fruits—with the exception of olives and grapes—are generally of minor importance, though in Lazio where market demands of a large city (Rome) encourage truck gardens, vegetables and fruits are abundant. Potatoes of Abruzzi reflect the mountain character of the interior.

Puglie should be differentiated as a sub-division, where natural conditions favor olives, which here reach the world's greatest concentration, while almonds and one industrial crop (tobacco) form deviations from the average.

While both Toscano and Umbria show influence of the neighboring division to the north and northwest without disturbing the general aspect of this type, Marche is definitely a transition in character. In many ways it resembles Emilia, but value of corn has decreased considerably and appearance of olives give it a Mediterranean touch.

Conclusion. The purpose of this article should be reëmphasized. It is above all the demonstration of a method which—as the author firmly believes—is of great value to the geographer as a means to study agricultural production from the geographical point of view. Though the author is conscious of its weaknesses, he believes that its advantages outweigh any defects it may have.

Italy serves experimental purposes. In many ways it is ideal because of its agricultural diversity and because before all, it is an agricultural nation, in which agricultural products constitute most of its wealth and embrace most of its trade. From the personal point of view the value of intimate knowledge of large parts of the country which the author had acquired through frequent visits and his love for the Mediterranean world as a whole, makes Italy first choice for the purpose.

FORDLANDIA AND BELTERRA, RUBBER PLANTATIONS ON THE TAPAJOS RIVER, BRAZIL

Joseph A. Russell

ONE of the geographic problems of the defense of the Western Hemisphere is the feasibility of the United States producing its own natural rubber within the confines of the Americas. Several agencies have indicated an active interest in this problem. One of these is the Ford Motor Company, which started rubber plantation operations in Brazil in 1929 with the objective of freeing the company from dependence on the distant *Hevea* orchards of the Middle East. Attainment of this goal will require about 76,000 acres of high-yielding trees, approximately one-sixteenth of the total needed to satisfy the normal rubber consumption of the United States.

It is a well-established policy of the Ford Motor Company to produce a large part of its basic raw materials. Mines, forests, and crop lands in many parts of the world are owned and operated by the company, and in 1927 a concession was secured from the State of Para, Brazil, for the purpose of establishing a rubber plantation in the Amazon basin. This concession applied to 1,000,000 hectares (2,471,000 acres) of presumably unowned land extending inland from the Tapajos River starting at a point 110 miles south of the Amazon, and some 650 miles from the Atlantic Ocean. Clearing began in 1929, but various serious production problems developed at this site, and in 1934 the State of Para exchanged the most remote 281,500 hectares (695,586 acres) of the concession for an equal-sized waterfront area only 30 miles south of Santarem (Figure 1).

The original concession area, named Boa Vista, but now known as Fordlandia, is at present being used almost exclusively as a research station and laboratory. Expansion activity is centered at the newer site, Belterra. More than 1,000 remote descendants of some of the *Hevea* seeds which Sir Henry Wickham collected around Boim (Figure 1) were brought back to the Tapajos when Belterra was established. These clonal seedlings, selected from the high-yielding plantations of the Middle East, have been used as bud grafting material on the Ford plantations.

Natural and Economic Requirements of a Rubber Plantation

Natural Conditions.—The natural requirements of the commercial *Hevea* species limit plantation development to the rainy low latitudes. The need for a constantly warm, moist climate is not particularly restrictive, because large areas near the equator have the necessary 70 to 120 inches of rainfall a year; but soil, drainage, and relief tolerances narrow the area satisfactory for plantations.

Deep, friable soils of at least moderate fertility are desirable, although fertility can be maintained by leguminous cover crops and fertilizers. Adequate soil drainage is, however, a definite restrictive requirement. Rubber is intolerant of poorly drained sites, and wide zones of low elevation and relief are therefore unfit for plantation investment. On the other hand, if the terrain is strongly dissected, clearing of the natural forest cover allows soil wash and necessitates expensive terracing and cover cropping.

The valleys of such areas are often poorly drained during the period of maximum rainfall. Thus the lands within the warm, moist low latitudes best suited to plantation production are those of low but definitely sloping surface, which possess a deep, friable soil. These conditions make the selection of a site for the plantation investment a primary consideration.

Other natural factors of site and position which must be fulfilled to insure the success of a rubber plantation impose further geographical limits. Water transportation should be available. The location of the plantation in respect to world trade routes and lands of rubber consumption must be considered in order to keep transportation costs at a minimum.

Cultural Requirements.—The success of a rubber plantation depends on the satisfaction of certain cultural requirements as much as on the suitability of the area for the growth of the trees.

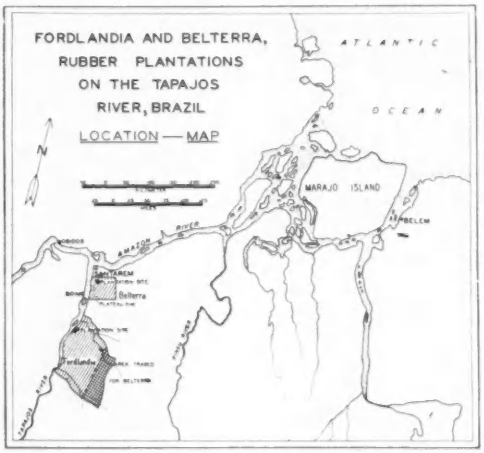


FIGURE 1.—Both Fordlandia and Belterra have easy access to water transportation on the Tapajos River. The downstream site of Belterra is accessible throughout the year by large steamers, but Fordlandia is beyond the limit of navigation during the dry season except for launches. The exact location of Figure 5 (Fordlandia Estate Map) and Figure 7 (Belterra Estate Map—1941) are shown as the "Plantation Sites" within the larger concession areas. (Compiled from the records of *Companhia Ford Industrial do Brasil.*)

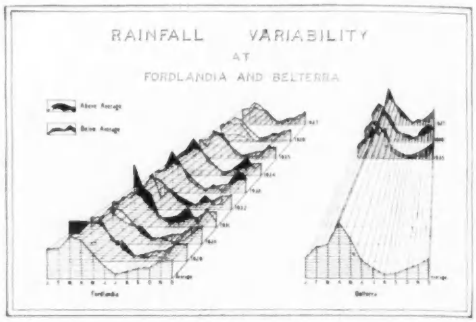


FIGURE 2.—Rainfall distribution and variability in the Tapajos region have proved a definite handicap to plantation operations. This diagram shows the nine-year average of Fordlandia and the three-year average of Belterra, together with the monthly deviations from that average for each year of observation. (Compiled from the records of *Companhia Ford Industrial do Brasil.*)

The most important of these human factors are labor supply and capital availability. In the Amazon region it requires about 600 man-days to underbrush and clear a 40-acre tract, an additional 80 man-days to line and stake the 40 acres, and 75 man-days to plant this amount of land. Bud grafting and tapping also demand large amounts of labor. One man can graft about one acre of trees a day, and after the plantation reaches tapping size, a single man can handle about seven acres. The labor requirement is numerically high, and in addition this labor must be efficient and at least moderately energetic.

The availability of capital is largely conditioned by the political stability of the region involved. The waiting period between the first investment and the initial sale of rubber is from five to ten years, although economic crops other than rubber are often planted to shorten the time before some revenue can be expected. The investment in a large modern plantation must be reckoned in hundreds of thousands of dollars, and such sums are not likely to flow into areas where there is doubt of the permanence of the concession.

In areas where all of the natural and cultural conditions for rubber growth are fulfilled, there may be unforeseen problems which will affect the success of the venture. Epidemics in the human or vegetal population may impose serious handicaps. Price fluctuations, the development of substitutes, and other economic and political events may utterly destroy the investment.

the rainfall tolerance of rubber, but they fail to indicate the erratic yearly conditions (Figure 2). In 1929 Fordlandia received a total of 102.5 inches and in 1930 only 70 inches. These consecutive years were the extremes recorded at this station during the nine-year period, but 1938 and 1939 had less than 70 inches. Rainfall at Belterra also shows great annual vari-

FIGURE 3.—The strongly dissected terrain at Fordlandia is clearly seen in this picture. Such land, made up of flat-topped erosion remnants, steep slopes, and ravines, proved an insurmountable obstacle to the development of a rubber plantation, and much of the area has been abandoned. The Tapajos River can be seen in the background. (Courtesy of Ford Motor Company.)

CONDITIONS FOR PLANTATION PRODUCTION

Climate.—Conditions of temperature in the Amazon basin are entirely suitable for rubber production. The yearly average in the Santarem district is in the neighborhood of 80 degrees F., with an annual range of less than 5 degrees F. (Table I). The mean maximum range is approximately 14 degrees F.

The experience of the Ford Motor Company indicates that the rainfall conditions in the Tapajos area are not altogether satisfactory for rubber. A nine-year average at Fordlandia shows 86.94 inches of precipitation a year, and a three-year average at Belterra is slightly higher, with 92 inches (Table I). Both of these averages are well within

ability. In 1935, 76 inches were measured and two years later the total was 107 inches (Table I). There is no direct correlation between conditions at the two sites. In 1935 rainfall at Fordlandia exceeded that at Belterra by seven inches, but in 1936 and 1937 the precipitation decreased at Fordlandia and increased at Belterra.

Both stations show the same general seasonal rainfall pattern and follow that for Taperinha, near Santarem. There is a period of high rainfall between January and May, and a dry season between July and October (Figure 2). In detail the Fordlandia maximum and minimum seasons begin about one month earlier than at the more northern stations, and end a month earlier. March

TABLE I

MONTHLY AVERAGES OF RAINFALL, FORDLANDIA AND BELTERRA, BRAZIL
MONTHLY AVERAGES OF TEMPERATURE AND RAINFALL, TAPERINHA, BRAZIL

	Jan.	*Feb.*	*Mar.*	*Apr.*	*May*	*June.*	*Jly.*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*	*Year*
Taperinha: (Temp.: 1914–1919. Rainfall: 1914–1923)													
Temp.	77.5	76.6	77.2	77.2	77.0	76.5	77.0	78.3	79.7	79.7	80.4	78.8	78.1
Rainfall	6.7	11.6	11.9	12.0	10.8	6.7	4.4	4.9	1.5	1.4	2.4	4.8	76.1
Fordlandia:													
Rainfall (1929–1939)	10.4	10.9	15.0	13.6	8.8	4.6	1.6	2.3	3.6	3.6	6.1	6.5	86.94
Belterra:													
Rainfall (1935–1937)	7.0	10.8	12.0	19.3	14.2	6.5	3.5	1.7	1.8	3.3	4.7	7.2	92.0

YEARLY TOTALS

Fordlandia		*Belterra*	
1929	102.5	1935	76.0
1930	70.0	1936	93.5
1931	93.5	1937	107.0
1932	91.5		
1933	95.5		
1934	99.0		
1935	83.0		
1936	75.0		
1937	74.0		
1938	64.7		
1939	62.3		

The data for Fordlandia and Belterra in Table I were furnished by the *Companhia Ford Industrial do Brasil*. The figures for Taperinha are from the *Directoria de Meteorologia*, Rio de Janeiro.

is the wettest month at Fordlandia and July the driest; at Belterra and Taperinha April is the wettest and August and October the driest months.

There are two deleterious effects of the seasonal distribution of rainfall at the Tapajos sites. The distinct seasonal trend, in which between 80 and 85 per cent of the rainfall occurs in seven months, lengthens the maturing period of the trees from the five to seven years usual in the Middle East to about ten years. In addition the "wintering" period, during which the trees shed their leaves, is intensified by the drought. Tapping is usually relaxed during this period.

The time of day in which the rain falls is an important factor in the development of a rubber plantation. Tapping is usually started at five or six o'clock in the morning and is concluded before noon because the flow of latex is greatest between dawn and nine o'clock. Rainfall during the tapping hours is considered to be disadvantageous because it may cause bark and wood acids to dilute the latex or to coagulate it prematurely. Rubber so affected can be worked into a marketable product, but costs are increased.

Although Belterra has a slightly higher annual rainfall than Fordlandia, the latter site is better favored in respect to morning rain. Between 1935 and 1937 precipitation was recorded on an average of 215 days at Fordlandia and 201 days at Belterra (Table IIa), but at Fordlandia only about one-quarter of those days received rain between 3.00 a.m. and 9.00 a.m. (Table IIb), while at Belterra showers occurred during the tapping period in about one-third of the rainy days.

TABLE IIa

RAINFALL BY DAYS, 1935–1937

Year	*Jan.*	*Feb.*	*Mar.*	*Apr.*	*May*	*Jne.*	*Jly.*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*	*Total*
Fordlandia													
1935	24	28	26	16	23	11	12	7	4	11	15	19	196
1936	25	24	23	25	21	18	15	10	11	11	11	10	204
1937	26	28	28	28	23	23	22	12	10	14	12	19	245
												Average	215
Belterra													
1935	16	25	19	19	22	23	17	9	8	11	12	17	198
1936	20	24	26	23	19	25	23	12	6	5	12	8	205
1937	17	18	23	25	26	26	17	8	7	8	12	14	201
												Average	201

TABLE IIb

DAYS WITH RAINFALL BETWEEN 3 A.M. AND 9 A.M., 1935–1937

Fordlandia													
1935	11	8	6	13	3	1	..	..	1	2	5	3	53
1936	9	12	5	10	7	2	1	3	2	3	3	4	61
1937	7	12	4	7	10	4	2	..	4	3	2	3	58
												Average	57.8
Belterra													
1935	4	7	8	11	9	4	5	..	..	2	2	3	55
1936	11	13	9	5	10	1	..	6	3	4	4	4	70
1937	11	11	12	20	5	5	4	..	2	..	..	5	75
												Average	65.7

AVERAGE PER CENT OF HOURS OF RAINFALL BETWEEN 3 A.M. AND 9 A.M.

Fordlandia	33.5	31.5	16.5	22.5	21.5	19.5	14.5	9.5	28.5	35.5	23.5	30.5	Average 24
Belterra	23.5	30.5	33.5	24.5	20.5	14.5	18.5	21.5	16.5	41.5	41.5	50.5	Average 28

The data for Tables IIa and IIb were supplied by the *Companhia Ford Industrial do Brasil.*

Fordlandia also shows a lower percentage of hours of morning rain than does Belterra.

At both plantations the number of days in which rain occurred during the morning was less than one-third of the total days with rain. The highest percentage of hours of morning rain occurred in October at Fordlandia and in December at Belterra. At Fordlandia the months of March to August receive less than the average per cent of hours of morning rain, and at Belterra this condition is delayed a month.

Except in 1938 and 1939 when the total rainfall at Fordlandia fell below that required for rubber, minimum climatic conditions for plantation rubber production are fulfilled at both Fordlandia and Belterra. The monthly distribution of rainfall is not ideal because of the dry season, but this should do little except retard the maturing age of the trees by two or three years and intensify the wintering period. The diurnal distribution of rainfall is satisfactory, and facilitates field activity.

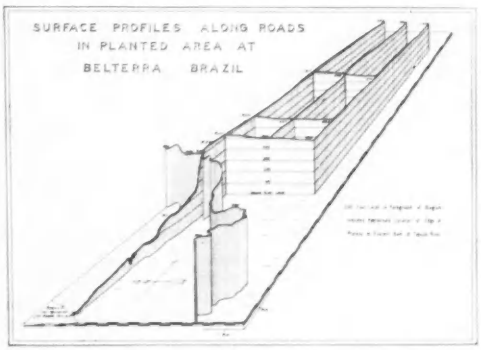


FIGURE 4.—The surface conditions at Belterra are ideal for plantation development. This series of profiles, based on levels run by company engineers, are projected along some of the roads in the planted area in this plantation. The locations of these profiles are shown on Figure 7 (Belterra Estate Map—1941). (Compiled from the records of *Companhia Ford Industrial do Brasil.*)

Natural Conditions of Relief, Drainage, and Soil.—The relief, drainage, and soil characteristics of the two Ford plantation sites show the potency of these factors as limits to successful cultivation of rubber. Climatically similar, the two plantations are on essentially different types of surface, and consequently drainage conditions are dissimilar.

The Tapajos River flows in a relatively narrow valley, and is confined on both sides by plateau walls. In places this wall has been strongly dissected, and the concordant summit levels are separated by steep-sided valleys. This rough surface of slopes, valleys, and isolated knobs extends eastward as much as seven miles before a sandy upland and high plateau is encountered. In other parts of the Tapajos valley the high plateau extends virtually to the river, and an abrupt escarpment towers more than 500 feet above the level of the stream. Eastward from this well-defined plateau rim the surface is smooth and dips southeastward at about seven feet per mile.

The two plantation sites represent both types of surface. Fordlandia was developed on the rough, dissected plateau remnant (Figure 3), and Belterra has been laid out on the smooth plateau top, within a short distance of the river (Figure 4).

Fordlandia.—The surface configuration at Fordlandia imposed heavy operating expenses, and subsequent abandonment of large areas (Figure 5). This site is rough, and has deep ravines with short, steep, gravelly and rocky slopes. Rock outcrops are frequent on the hill tops and sides. This type of land surface resulted in an irregular planted area (Figure 5), expensive terracing of slopes, and cover cropping (Figure 6). Complete withdrawal of operations was enforced in several areas.

Under conditions of natural rainforest cover the soil on the steep slopes did not wash seriously, but once the trees were removed, soil erosion control became a major problem at Fordlandia. Contour terracing and cover cropping were employed, and both are expensive techniques. Terracing added $23.17 per acre to the opening costs, and in 1932 and 1933 the cost of planting cover crops was $10,378.70. (All sums in this article are expressed in American dollars, and have been transposed from the Brazilian monetary units at the rate of one milreis to $.0515, the exchange quoted on May 26, 1941.) The leguminous cover crops, such as *Calopogonium*, *Centrosema* and *Pueraria* have the multiple use of soil conservation, shading the soil and thus increasing rainfall effectivity, reducing weeding costs, and increasing the humus and nitrogen content of the land.

In addition to the problems of soil erosion control imposed by the broken surface at Fordlandia, the valley bottoms proved to be poorly drained, and as a result unfit for cultivation. Tracts of low-lying land were cleared and planted, but because of high maintenance costs and low test yields, such

areas have been abandoned. The total of condemned land in March, 1941, was 3,425.95 acres.

Soils at Fordlandia are moderately suitable for rubber cultivation, except in the poorly drained ravines and on the gravelly, rocky hill sides. The undisturbed top soil is six to eight inches thick and overlays a firm, plastic red clay which is hard and poorly penetrable when exposed, and is often mixed with hard lateritic formations. Such a soil is moderately productive, but it induces a slow growth, especially if the friable

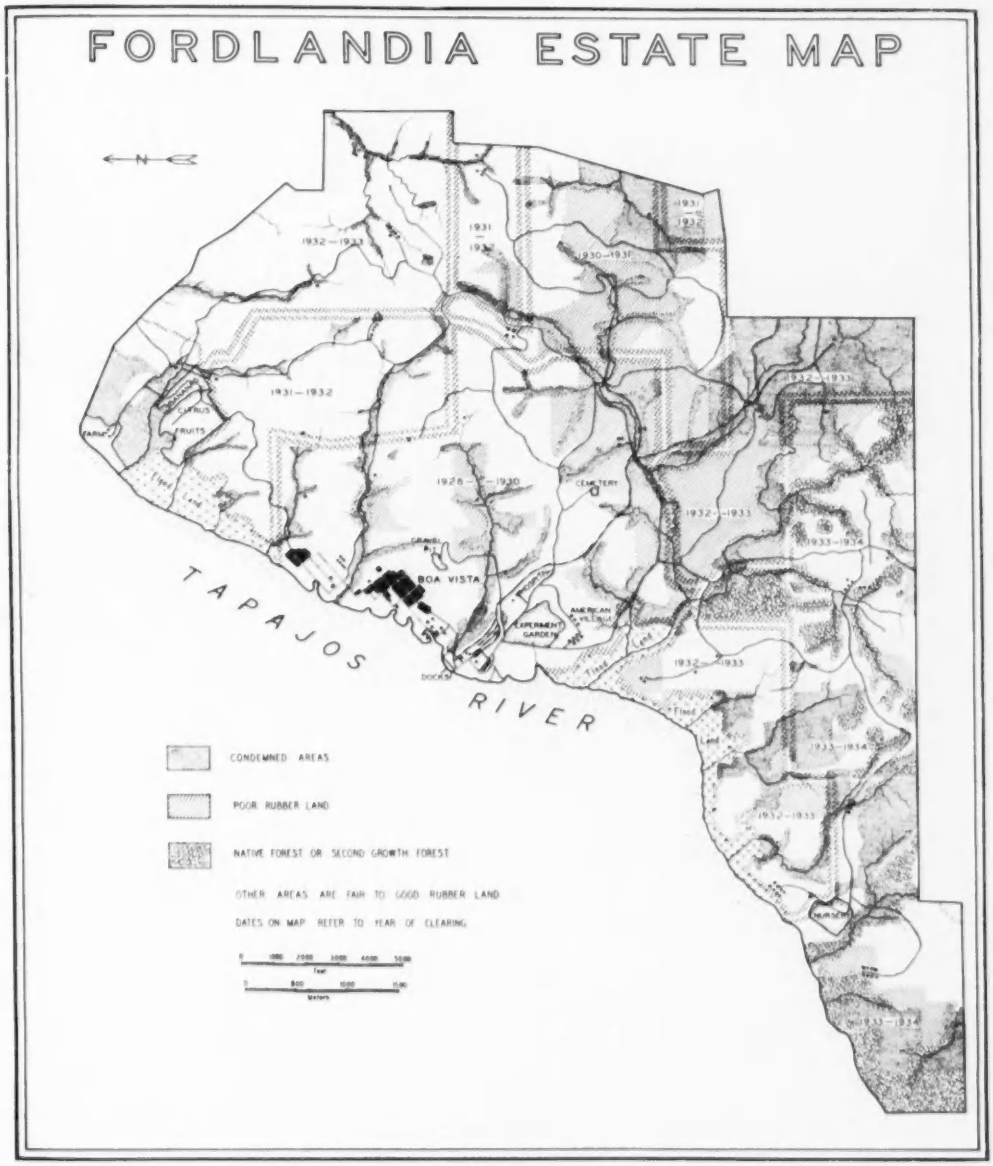


FIGURE 5.—This map shows the serious problem of plantation layout which presented itself at Fordlandia. The rough surface proved to be impossible rubber land, and resulted in the abandonment of large zones. Other large areas are classified as "poor rubber land," while only small tracts are truly satisfactory for plantation development. (Compiled from the records of *Companhia Ford Industrial do Brasil*.)

top soil is washed off. The combination of this soil type with an excessively hilly surface necessitates careful selection of plantable areas, the best of planting material, and expensive soil conservation and planting techniques. Fordlandia presents most of the natural obstacles to rubber planting in the Amazon region, and areas which have proved even moderately satisfactory have been maintained and are being used as laboratories for disease control and planting technique experiments.

FIGURE 6.—Expensive terracing and cover cropping were necessary at Fordlandia. This picture shows a newly planted area on this plantation, with the white-topped stakes along the terraces indicating the location of seed beds. Areas such as this are poorly drained during the wet season and have been abandoned. Such steep slopes wash seriously and the terraces and cover crops are designed to prevent erosion. (Courtesy of Ford Motor Company.)

Belterra.—The area in the vicinity of Boim is reputed to be the best rubber land in the Amazon basin, and conditions of relief, drainage, and soil at Belterra support this reputation. Absolute freedom of plantation layout is allowed by the smooth plateau surface (Figure 7). Adequate drainage is provided by the dip of about seven feet per mile toward the southeast. Figure 8 indicates that there is a 47-foot layer of yellow clay subsoil at Belterra, but the top soil is friable and well adapted to rubber cultivation. No rock was encountered in drilling two 500-foot wells, the entire depth being composed of sands, clays, and pebbles. The water table was 375 feet below the surface.

The surface profile (Figure 4) shows the gentle slope to a bench at the base of the plateau escarpment, then the sharp rise to the plateau itself within a distance of three and a half miles. At other places shown in the Belterra Estate Map (Figure 7) the plateau rim lies within a quarter-mile of the river. The bench along the surface profile is planted to experimental rubber, while the featureless upland above the rim is the site of the main plantation (Figure 9). Here soil wash is unimportant and great savings in operating overhead are enjoyed because cover crops and

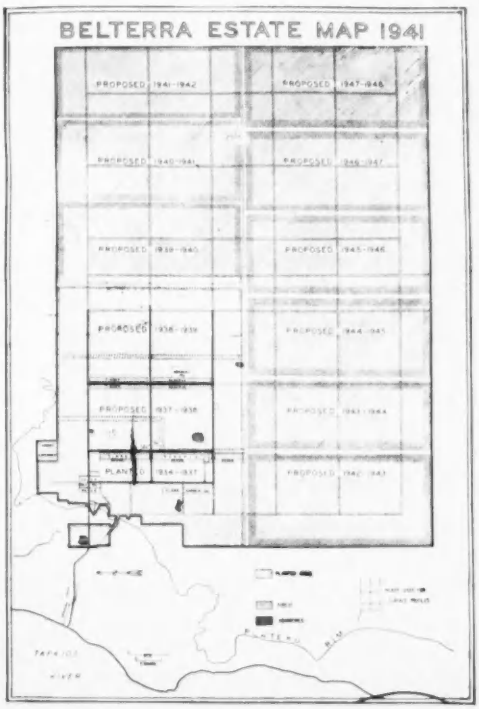


FIGURE 7.—Right-angle plantation pattern allowed in the development of Belterra. The original plan was to clear and plant about 5,000 acres a year, but lack of labor has necessitated drastic revision of this program. The map shows progress to December, 1941, and indicates how far behind schedule the planting has become. (Compiled from the records of *Companhia Ford Industrial do Brasil.*)

terraces are not necessary. It has been possible to lay out the Belterra plantation on a rectangular pattern, with roads, tree lines, operation units, etc., all oriented on a straight line 40-acre plot system (Figure 7).

Position of Fordlandia and Belterra in Relation to Water Transportation.—Both Fordlandia and Belterra have ready access to water transportation on the Tapajos River. The accepted limit of navigation for vessels of as much as 400 tons is about 175 miles from Santarem, well upstream from Fordlandia. However, the Tapajos River level fluctuates as much as 40 feet between its flood height and low water periods, so that except for small launches, Fordlandia is outside the dry season limit of navigation. Belterra is accessible by river steamer throughout the year, thereby achieving another advantage over Fordlandia. Belterra is about 530 miles from Belem, formerly one of the most important rubber market places of the world.

Rubber Diseases on the Ford Plantations.—The presence of several fungus and insect diseases has proved a handicap to the development of Fordlandia

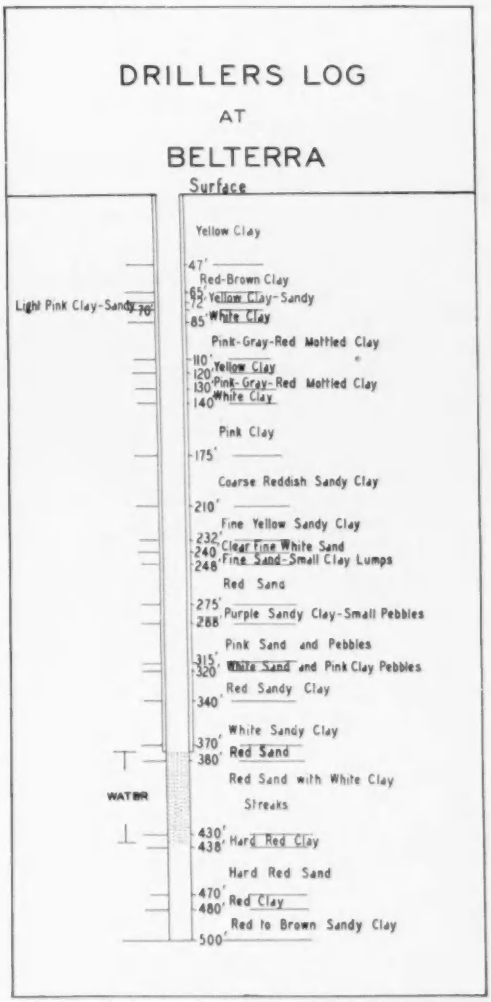


FIGURE 8.—Clay predominates through the entire 500-foot depth of this well at Belterra. The water table was encountered at 375 feet below the surface. (Compiled from the records of *Companhia Ford Industrial do Brasil.*)

FIGURE 9.—General view of Belterra showing its smooth surface. A right-angle pattern of clearing and planting is possible at this site, whereas the hills of Fordlandia imposed an irregular layout. The land on the left of the road has been planted to rubber. (Courtesy of Ford Motor Company.)

and Belterra. South American Leaf Wilt and the lace bug are the most serious. Both are now under some sort of control. Conditions of poor drainage at Fordlandia allowed the incubation of several diseases.

Disease control has been accomplished by importing disease resistant species of *Hevea*, by grafting, and by spraying. Leaf disease was attacked by the expedient of bringing in seeds from Marajo Island, at the mouth of the Amazon (Figure 1). Trees from Marajo Island seeds show a strong immunity to the leaf disease. Because yields from these trees are low, high-yielding clonal stock has been grafted to them. However, clonal *Hevea brasiliensis* leaves are more subject to attack of the lace bug than the thicker leafed *H. benthamiana*, *H. spruceana*, and *H. guyanensis*. This situation necessitated a second grafting operation, and a new clone, composed of native Marajo seedlings, high-yielding eastern clonal trunk, and a lace bug resistant crown has been developed (Figure 10). This three-part tree seems to hold promise of obviating the effects of leaf disease, and is expected to produce 1,200 to 1,400 pounds of latex per acre.

FIGURE 10.—The occurrence of several rubber tree diseases and pests at Fordlandia necessitated development of a new clone. This tree, shown in full leaf in the midst of a denuded group, is the result of the experiment. A crown of *Hevea guyanensis* has been grafted to a clonal trunk which had been previously grafted to Marajo Island root stock. Note the darker bark of the tree above the graft in both this tree and the one directly behind it. (Courtesy of Ford Motor Company.)

Certain insects are not checked by the new trees, and other methods have been necessary to control them. *Timbo*, the fish poison plant, contains rotenone, an effective insecticide. This plant grows abundantly in the Tapajos area, and cultivated *timbo* is crushed and sprayed on the trees.

Fordlandia is more seriously affected by fungus and insects than Belterra. Its varied conditions of drainage and slope offered an environment which encouraged the development of diseases and pests, whereas the more uniform conditions at Belterra, although not entirely discouraging disease, presented less opportunity for their development. Experience in disease control gained at Fordlandia has prevented the inception of epidemics at Belterra.

The natural handicap of vegetal disease on the Ford plantations is, then, being overcome. The presence of diseases and pests has increased costs and caused withdrawal from several areas, but will not have a determining effect on the long term success or failure of the venture.

Cultural Conditions of Land and Capital.—Land and capital are available in amounts large enough to insure the success of the plantation experiment if

other requirements are fulfilled. The State of Para originally ceded 1,000,000 hectares of land (2,471,000 acres) for the Fordlandia site, and when the natural conditions of this area proved undesirable for a rubber plantation, the state traded 281,500 hectares (695,586 acres) of more suitable riverfront land for the most inaccessible part of Fordlandia. This exchange took place in 1934. The Ford Motor Company has invested nearly $9,000,000 in the two sites.

The terms of the original concession imposed several conditions which affected the development of Fordlandia. Chief among these was the stipulation that the "concessionaire undertakes to plant rubber trees on . . . 400 hectares (988.4 acres) the first two years, 400 hectares during the third year, and 400 hectares during the fourth year." This stipulation necessitated clearing and planting without adequate land inventory and planning. Many of the subsequent problems at Fordlandia generated in this planting guarantee.

Other clauses of the concession of 1927 gave the company almost complete control over the area. The company obtained the rights of proprietorship, building any kind of structure without state supervision, exporting and importing raw or processed goods, promoting settlement, mineral exploration, establishment of communication facilities, and exemption from state and municipal taxes for a period of fifty years. In return the Ford Motor Company undertook to establish a rubber plantation, supply hygienic and sanitary facilities, schools, and, after the first twelve years, to give five per cent of its net profits from the sale of rubber to the State of Para and two per cent to the interested municipalities.

FIGURE 12.—This oblique aerial photograph shows the nodal point of the original plantation on the Tapajos River. The picture is oriented toward the north. The lumber mill and yard, the docks, and the laboratories are in the foreground, and the workers' homes are in the background. The broken nature of the land can be seen to the east of the village. (Courtesy of Ford Motor Company.)

FIGURE 11.—The immense investment necessary to establish a rubber plantation in Amazonia is shown by this general view of the town of Boa Vista at Fordlandia. There are some 300 buildings in this village, all of which were built at company expense. (Courtesy of Ford Motor Company.)

The liberal terms of the concession indicate the willingness of the State of Para to coöperate with the plan to develop a rubber plantation within its limits. The federal governments of Brazil and the United States have recently interested themselves in the rubber potential of the Amazon basin as well as other South and Central American areas, and will undoubtedly draw heavily on the experiences of the Ford plantations in an attempt to avoid some of the difficulties to the establishment of plantation production in these places.

TABLE III

EQUIPMENT AND LABOR EXPENSE, FORDLANDIA AND BELTERRA, DECEMBER, 1939, MAY, 1940, AND MARCH, 1941

Equipment Item	Fordlandia			Belterra		
	Dec., 1939	*May, 1940*	*March, 1941*	*Dec., 1939*	*May, 1940*	*March, 1941*
Cars, number	3	3	3	6	6	7
Trucks, number	13	11	13	33	33	36
Gasoline used, gallons	497	680	755	3,049	3,644	5,319
Kilowatts produced	38,702	37,504	37,181	16,000	16,000	45,400
Fuel oil used, gallons	2,638	3,260	3,087	4,576	4,948	4,959
Water used, gallons	2,900,000	2,149,000	2,245,000	1,500,000	1,500,000	5,270,000
Buildings, straw	28	24	24	553	675	808
Buildings, frame and block	247	247	241	81	84	148
Buildings vacant, straw	5	5	..	..	..	..
Buildings vacant, frame and block	52	51	53	8	10	7
Latex shipped, pounds	..	1,064	34,219	..	..	..
Employees, number hourly and task	331	312	308	848	1,350	1,637
Employees, salary	20	21	18	32	33	44
Employees, staff	2	2	1	6	7	8
Employees, contract	17	17	24	679	710	702
Payroll, hourly	$3,834.60	$3,594.21	$3,234.41	$7,886.20	$11,924.30	$14,210.04
Payroll, salary	$1,454.87	$1,478.47	$1,332.16	$2,241.53	$2,398.61	$3,093.64
Payroll, contractors	$1,458.58	$1,155.42	$950.07	$3,210.94	$2,823.72	$3,165.80
Payroll, Belem	$102.48	$53.13	$40.42	$277.07	$326.41	$363.84
Total payroll	$7,129.96	$6,549.62	$5,690.10	$19,230.05	$22,473.72	$25,710.58

Data for Table III were furnished by the *Companhia Ford Industrial do Brasil.*

NEED FOR CAPITAL

The Ford Motor Company has been developing its plantations in Brazil for twelve years, and has invested something like $9,000,000 in the project, yet production of rubber has only started. For several years creamed latex has been shipped to the Ford tire factory at Dearborn, Michigan, but until recently such shipments have been small, such as 6,334.5 pounds in March, 1939, and 1,064 pounds in May, 1940. In March, 1941, the shipments had reached 34,219 pounds a month, and it is estimated that total production will be in the neighborhood of 1,000,000 pounds in 1941. These consignments have originated at Fordlandia. Commercial tapping at Belterra is expected to begin in 1942–1943, but since only about 15,000 acres at this plantation were planted in December, 1941, and about half of this was budded, production from the present orchards of both plantations will satisfy only a small part of the Ford needs.

During the twelve-year waiting period expenses have been high. Table III shows the amount of equipment and the payroll expense of the two plantations during selected months in 1939, 1940, and 1941. There are over 1,000 buildings of all types on the two sites. These include radio stations, powerhouses, refrigeration and water purification plants, hospitals, schools, sanitary and research buildings, warehouses, stores, staff houses, office buildings, dormitories, and workers' homes (Figures 11–15). It is noticeable in Table III that there has been steady withdrawal of equipment and labor from Fordlandia and a steady increase at Belterra.

Nearly all new construction is being undertaken at Belterra. In 1939 new buildings at this site cost $53,378.57, and in 1937 the average monthly labor and material cost at Belterra was $14,080.10, compared with $4,454.75 at Fordlandia. Floating overhead expenses were $9,334.37 per month during 1937 at Fordlandia and $7,351.62 at Belterra.

Many efforts have been made to derive some subsidiary income from the plantations. Through the sale of various services Fordlandia received a sum approximately 12 per cent as large as its floating overhead expense per month between July, 1936, and January, 1938; while Belterra received an amount about four and a half per cent as large as its floating overhead during that period.

Attempts to achieve a measure of self-sufficiency have resulted in a small income to the company. Many crops, such as mandioca, the staple food of Brazilian labor, castor beans, Manila hemp, jute, ginger, cinnamon, tea, coffee, citrus fruits, pineapple, bananas, various vegetables, kapok, eastern gutta-percha, balata, chicle, tung, balsa, and soy beans have been planted with variable success. A 318-acre farm was set up to furnish much of the food, including livestock and chickens, needed by the plantation staff at Fordlandia. Various factors have led to the abandonment of much of this farm. Most of the present food production on the two sites is undertaken by the laborers' families (Figure 16), and the produce is consumed directly by them.

FIGURE 13.—Because of the serious scarcity of labor in the Tapajos area, great care is taken to furnish comfortable quarters for the workers. These buildings are the dormitories for single men at Fordlandia. Houses are given to married men, and all workers are supplied with free hospitalization, water, light, and garden space. (Courtesy of Ford Motor Company.)

Table IV gives the detailed cumulative expense items, excluding fixed overhead, of the two plantations up to December, 1939, May, 1940, and March, 1941. The

TABLE IV

EXPENSES, DECEMBER, 1939, MAY, 1940, AND MARCH, 1941 AT FORDLANDIA AND BELTERRA

(Fixed Overhead Not Included)

Item	Belterra			Fordlandia		
	Dec., 1939	*May, 1940*	*March, 1941*	*Dec., 1939*	*May, 1940*	*March, 1941*
Nursery	$1,903.56	$2,107.84	$9,821.78	$26.69	$91.42	$493.82
Maintenance	60,236.29	18,504.74	103,536.38	23,195.47	3,362.24	15,733.24
Bud graft	7,184.63	4,003.20	9,642.24	.....	.....	.....
Tapping	.....	.....	.....	3,274.23	153.80	4,401.25
Research	459.20	.....	.....	539.81	.....	.....
Logging	1,807.38	277.99	3,852.06	.....	.....	.....
Sawmill	684.40	128.32	1,369.50	.....	.....	.....
Total direct	$72,326.06	$25,167.31	$136,012.37	$26,942.70	$3,985.46	$21,440.88
Construction	38,573.95	10,560.10	80,776.88	258.67	181.52	2,040.59
Floating overhead	148,018.16	37,443.66	238,040.35	67,916.61	12,509.95	77,714.72
Misc. Equip.	13,511.64	4,963.13	20,177.68	1,082.09	78.11	1,787.07
Total	$271,429.83	$78,084.22	$475,017.41	$96,200.08	$16,755.06	$102,974.27
Budget	$408,592.16	$437,404.15	$437,404.15	$178,040.38	$103,688.00	$103,688.00
Spent to date	279,844.77	70,906.17	426,381.57	102,462.24	15,603.14	95,901.03
Balance	$129,747.39	$366,497.98	$11,022.58	$75,578.14	$88,084.86	$7,786.97

The data for this table were furnished by the *Companhia Ford Industrial do Brasil.*

FIGURE 14.—Looking south along the eastern bank of the Tapajos River past Boa Vista, the large area of flooded land can be seen behind the wooded spits. The group of houses and gardens in the immediate foreground are provided to plantation workers. (Courtesy of Ford Motor Company.)

budget year at the plantations begins in April. Significant facts shown by Table IV are:

1. Nursery expense in 1941 at Belterra is twenty times as large as that at Fordlandia.

2. The differential in maintenance costs between the two plantations increased from about two and a half to one in 1939 to nearly seven to one in 1941. At both times Belterra received the major share of this expenditure.

3. All bud grafting expense was at Belterra, and all tapping expenditure was at Fordlandia.

4. Logging expense at Belterra declined between 1939 and 1940, but increased sharply in 1941. Three thousand acres were cleared and planted in 1941.

5. Total expenses at both plantations are in the neighborhood of $45,000 a month, about 80 per cent of which is spent at Belterra.

PRESENT STATUS OF THE FORD PLANTATIONS

Table V indicates the total results to March, 1941, of the expenditure of some $9,000,000, twelve years of effort at Fordlandia and seven years of development at Belterra. At this time 16,980.09 acres of trees were being maintained, and the 1941 planting brings the total acreage to nearly 20,000.

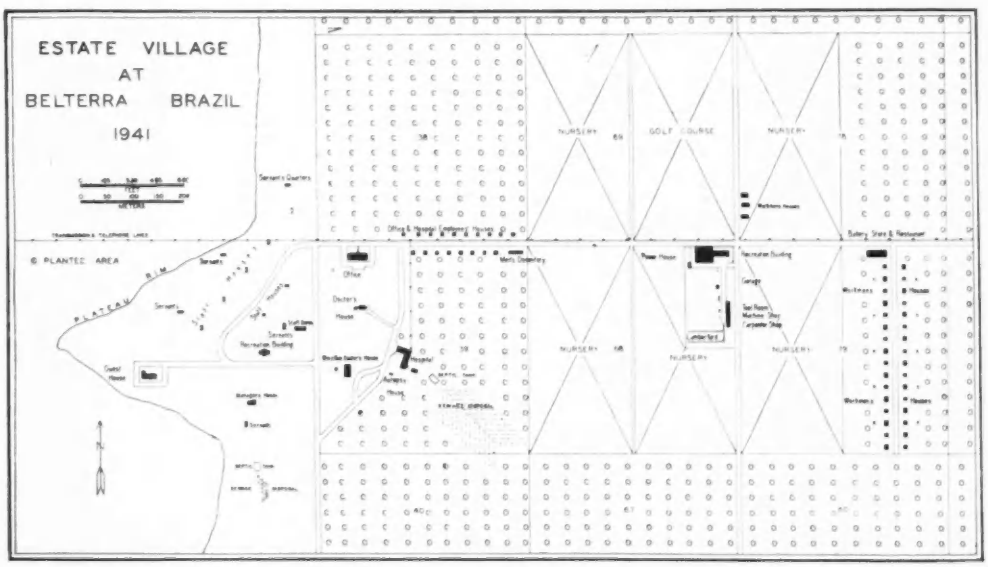


FIGURE 15.—The establishment of a rubber plantation entails a huge investment in buildings and equipment. Each estate must have a village which includes nearly all urban functions, including hospital, sewage disposal facilities, dwellings, offices, radio station, schools, recreational facilities, stores, and fire protection. (Compiled from the records of *Companhia Ford Industrial do Brasil*.)

FIGURE 16.—The native laborers are given free garden land to produce some of their own food. This vegetable garden is one of the plots devoted to the production of sustenance crops. (Courtesy of Ford Motor Company.)

Such an area is about one-quarter of the acreage required to supply the Ford Motor Company, and only during the last year have trees come into tapping in appreciable numbers. The 1,383 estate trees in tapping during May, 1940, provided only 148.8 pounds of latex, but the 88,500 tapable trees of March, 1941, yielded 35,015 pounds. Present production is about 2,000 pounds of latex a day.

Although progress is being made at Belterra, the rate of expansion is slower than originally planned (Figure 7). Between December, 1939, and March, 1941, only 83.61 acres of new plantation and 18,394 new trees were added at Belterra, although 370,129 trees were budded. However, by December, 1941, an additional 3,000 acres were cleared and planted at this site. During the period covered in Table V the planted and maintained area at Fordlandia shrank nearly 2,000 acres as condemnation of poorly drained zones became advisable.

Summary of the Need for Capital.—The preceding section shows the large amounts of capital needed to develop a rubber plantation and the length of time required in Amazonia before any considerable return can be expected. Expenditures indicate that Fordlandia has not been abandoned as a plantation site, but that it has been limited to its present size, and will be used in the future as an experimental station.

This discussion also indicates that although Belterra is receiving the major share of current investment, its development is slow. Despite the suitability of the site to plantation investment from the standpoint of land and climate, the availability of capital, proximity to cheap transportation throughout the year, and position in regard to market for the product, new planting has fallen short of the planned rate of 5,000 acres a year. The actual expansion has taken place at about 2,300 acres a season.

REASONS FOR THE SLOW DEVELOPMENT

There are three reasons for the slow development of the Ford plantations. Most important is the scarcity of labor, although presence of rubber diseases

TABLE V

SUMMARY OF RESULTS AT FORDLANDIA AND BELTERRA, DECEMBER, 1939, MAY, 1940, AND MARCH, 1941

Item	Belterra			Fordlandia			Total
	Dec., 1939	*May, 1940*	*March, 1941*	*Dec., 1939*	*May, 1940*	*March, 1941*	
Acres planted	12,146.48	12,230.09	12,230.09	6,444.01	6,444.01	4,750.00	16,980.09
Acres in budwood	312.04	217.21	217.21	.....	.....	.....	217.21
Acres in isolation	40.06	40.06	40.06	.....	.....	.....	40.06
Condemned acres	.....	.....	.....	1,731.94	1,731.94	3,425.95	3,425.91
Research acres	179.41	179.41	179.41	11.67	11.67	11.67	191.08
Farm acres	59.33	59.33	59.33	25.18	25.18	25.18	84.51
Camps and towns (acres)	336.33	338.33	338.33	127.36	127.36	127.26	465.69
Roads, miles	43.00	43.00	43.00	28.20	28.20	28.20	71.20
Trees planted, number	2,672,225	2,690,619	2,690,619	839,212	839,212	685,148	3,375,767
Trees budded	983,159	1,353,288	1,353,288	40,124	40,124	37,608	1,390,896
Seedlings in budwood gdns.	300,000	301,473	301,473	.....	.....	.....	301,473
Seedlings budded in budwood gdns.	288,000	245,473	245,473	.....	.....	.....	245,473
Trees in isolation	4,578	4,578	4,578	.....	.....	.....	4,578
Trees in condemned areas	.....	.....	.....	40,000	40,000	194,064	194,064
Estate trees in tapping	.....	.....	.....	691	1,383	88,500	88,500
Latex produced (lbs.)	.....	.....	.....	111.9	148.8	35,015	.....

Data for this table were furnished by the *Companhia Ford Industrial do Brasil*.

and pests, and protracted drought and highly variable rainfall have also caused considerable disruption of the original planting schedule. The difficulties of operation have been more or less satisfactorily solved, and the climatic conditions, although not ideal, satisfy the minimum requirements of the *Hevea*. The lack of a suitable labor supply has, however, proved to be a definite restraining factor.

An abundant supply of cheap, efficient labor is one of the principal cultural needs of a successful plantation. This requirement cannot be satisfied within Brazil. The writer has published an article dealing in detail with the labor problem of the Ford plantations, and will summarize his findings here:

1. The labor force of the plantations was 2,723 in March, 1941.

2. A producing plantation of 76,000 acres, which is the goal of the concession, would need about 11,000 tappers alone, and nearly as many maintenance and service personnel.

3. Neither the Amazon basin nor adjacent areas, including northeastern Brazil, can supply this need. Low population densities, poor health, disinclination to work on the part of the natives who are without employment, and a labor shortage of those who can and will work, make it impossible to recruit the necessary men in Brazil.

4. The rubber lands of Amazonia have a bad reputation among Brazilian labor, and workers who are free to move prefer to migrate to Sao Paulo where there is a labor shortage.

5. Importation of labor from abroad is difficult because of the immigration restrictions of Brazil, and emigration conditions imposed by the governments of areas which have excess population of the type desirable for a plantation.

6. Costs of importing labor from outside Brazil are excessive.

7. A small increment of labor can be expected each year from within Brazil, but unless workers can be induced to the Tapajos region in large numbers, the expansion rate, and perhaps the final size of the Ford plantations will have to be revised.

Table VI emphasizes the expansion program in force at Belterra as compared with Fordlandia. The general trend

FIGURE 17.—The first step in clearing the land is "underbrushing" by contact laborers. A 40-acre plot is the clearing unit, and 20 men are used for each such area. (Courtesy of Ford Motor Company.)

of employment at Belterra has been upward, while the number of workers at Fordlandia has decreased about one-half during the period covered in Table VI. The employment figures for Belterra show wide fluctuations. During the dry season employment is low, and the wetter months show a higher number of workers.

Labor Conditions.—Every effort is made to maintain high living standards for the laborers on the Ford plantations. When a worker is hired, he is assigned to a dormitory if he is a single man (Figure 13), or a house and garden if he is married. House, garden plot (Figure 16), light, water, hospitalization, and recreational facilities are provided free. Wages are 35 per cent higher than the average for the Amazon region, and food and other commodities are supplied at concessions where prices are carefully controlled to avoid excessive profit taking on the part of the concessionaire.

The total population of the two plantations is approximately 12,000. Careful selection of workers and the hygienic precautions maintained by the company have resulted in a health condition of these people which is better than the general situation in Amazonia.

TABLE VI

NUMBER OF EMPLOYEES, FORDLANDIA AND BELTERRA

Date	*Belterra*	*Fordlandia*	*Total*
October, 1935	638	640	1,278
December, 1935	650	681	1,331
March, 1936	1,077	680	1,757
July, 1936	303	557	860
October, 1936	555	427	982
December, 1936	686	435	1,121
March, 1937	843	501	1,344
July, 1937	625	478	1,103
March, 1938	1,293	554	1,847
June, 1940	1,998	318	2,316
March, 1941	2,383	340	2,723

OPERATIONS AT THE FORD PLANTATIONS

There are several operations required to transform the Tapajos rainforest into an orderly rubber plantation. These

FIGURE 18.—The large size of some of the trees found in the natural forest of the plateau presented serious difficulties to fast clearing. The wood of some of these trees was so hard that it constantly dulled the cutting instruments. (Courtesy of Ford Motor Company.)

FIGURE 19.—A cleared area at Fordlandia. The larger limbs have been lopped off the fallen trees so that they will lie close to the ground and thus burn more effectively. (Courtesy of Ford Motor Company.)

steps are listed and briefly explained below:

1. The area to be cleared is laid out in forty-acre plots, and clearing lines are cut through the forest.

2. The first step in clearing is to "underbrush" the plot (Figure 17), that is, to cut all vines, saplings, and undergrowth of not more than one and a half inches diameter. While underbrushing is going forward, part of the crew begins felling the large trees and lopping off their branches (Figure 18).

The felled timber is allowed to lay for about 90 days before it is burned over (Figure 19). Many of the species on the plantations have a commercial value, and several of the wood buildings on the estates have been built with local timber. Some of the hardwood lumber was exported to Detroit. The most important trees at Belterra are *Andiroba* (Brazilian mahogany), *Castanha* (Brazil nut), *Cedroana* (Spanish cedar), and *Massaranduba* (a heavy hard wood used for railway ties, etc.). Nearly 100 varieties of trees have been identified at Fordlandia.

3. Burning is usually started in November (Figure 21). This process is not intended entirely to destroy the heavier trunks and boughs, and the area is burned over only once, because repeated fire destroys the humic content of the soil.

4. The area is next lined and staked, and holes are dug at 15-foot intervals. The seed beds are 24 inches square, and the dirt is removed to a depth of at least 12 inches.

5. Planting takes place at the beginning of the rainy season. Five or six seeds are placed in each seed bed. One of the major objectives of the Ford operations has been to develop planting material suitable to the Tapajos region.

Planting Material.—The Fordlandia planting material was made up entirely of native stock. Early plantings proved unsatisfactory, and the accumulation of five years of unsuccessful operation at Fordlandia led to the following conclusions, which culminated in the establishment of Belterra:

1. Tree disease became particularly virulent when the native rubber trees were congregated on plantations, and therefore disease resistant species of *Hevea* had to be found.

2. Native trees could not equal the

FIGURE 20.—After the underbrush has been cleared from the forest floor the larger trees are felled. Many of these logs are loaded on cars or trucks and carried to the mill to be made into saw lumber. (Courtesy of Ford Motor Company.)

10–17 pound annual yield of clonal varieties, and it would be desirable to stock Belterra with clonal species, bred to resist disease and also yield large quantities of latex.

3. Several areas at Fordlandia were unsuited to plantation production, and should be abandoned (Figure 5). These findings resulted in an essentially new mode of developing planting material. Fifty-six of the highest yielding Middle Eastern clones were imported and planted in nurseries at Fordlandia. Out of a total 2,046 clonal seedlings selected and shipped from Malaya, Java, and Sumatra, 1,201 grew in the nurseries, and began to produce shoots which were grafted to native stock. Today there are some 76 different clones growing in the Fordlandia and Belterra nurseries.

The planting material now used at Belterra consists of seeds from Marajo Island, which are transformed into high-yielding clonal species by bud grafting (see below).

6. Maintenance, weeding, culling, and replanting are important steps in the development of the plantation. By three or four months after planting the seedlings are usually three to four inches high, and two of the five seeds have grown more vigorously than the rest. These two are allowed to grow, and the others are pulled. In the event that none of the seeds get a good start, the entire planting may be discarded and a new start made. This replanting involves increased opening costs, but the long-term economies of the technique make it advisable. Culling out the weakest individuals leaves from 200 to 220 strong seedlings per acre.

7. Bud grafting takes place when the seedlings are about one year old, and have a trunk diameter of from three-quarters to one and a half inches at three inches above the ground. The technique of grafting allows the development of a tapable tree which has roots of native stock and a high-yielding clonal trunk. An additional graft used at the Ford plantation combines the native root, clonal trunk, and a crown of leaf disease resistant *Hevea benthamania*, *H. spruceana*, or *H. guyanensis* (Figure 10). Bud grafting began at Belterra in 1937, and by June, 1941, nearly 1,500,000 trees had been budded. This was about one-half of the total number of trees planted at that time. One trained man can graft about 200 trees a day, and the rate of survival fluctuates between 50 and 90 per cent.

FIGURE 21.—Felled timber and underbrush are burned over at the end of the dry season. The burn is not intended entirely to destroy the fallen trees, but rather to clear the ground enough to facilitate planting. (Courtesy of Ford Motor Company.)

The development of a high-yielding and disease resistant "parent tree" in the estate nurseries is vital to the successful production of rubber. One exceptionally good parent tree can supply buds for several hundred acres of seedlings, and great emphasis is placed on breeding a few such trees at Fordlandia and Belterra.

8. The budded trees are inspected monthly, and are pruned four times a year so that there will be no branching less than six or seven feet from the

ground. This is done to keep the tapping panel clean.

9. Test tapping is commenced when the budded trees are six inches in diameter at 20 inches above the ground. This size is usually attained during the fifth year. Test tapping indicates how much latex each individual tree is capable of producing, and the test is used to select the best trees in each acre. Only 100 of the 200 to 220 trees per acre are maintained after test tapping.

The first test tap at Fordlandia took place in 1937, and since that time creamed latex has been shipped to Dearborn, Michigan, nearly every month. Testing is now under way among the 1935–1937 plantings at Belterra.

10. Commercial tapping may be started when 50 to 60 per cent of the stand has reached a size of 20 to 40 inches diameter at three feet above the ground. This size will be attained by the early Belterra plantings in 1943, and test tap indications are that yields should average in excess of 1,000 pounds of latex per acre. The production per acre from budded trees increases from 200 pounds at the first tap to about 900 pounds by the eighth year. Thereafter the yield is approximately 1,000 pounds per acre for the life of the orchard, which is calculated at 30 years for accounting purposes, although the company expects to receive longer service from most of its plantings. The yield from unbudded trees increases from a 45-pound per acre first tap to about 450 pounds by the tenth year of tapping (Figure 22).

FIGURE 22.—A laborer tapping a native tree on the Ford concession. The trunk of the tree shows the scars of previous tapping just above the present tapping panel. Note the special knife used to shave off a thin section of the outer bark. (Courtesy of Ford Motor Company.)

The labor needed to tap trees on a commercial scale is greater than that for clearing, planting, and maintenance. Depending on the surface configuration, spacing of the trees, etc., one man can tap between 300 and 350 trees a day on alternate days. Each tapper, then, is in charge of 600 or 700 trees planted on six or seven acres. The estimated 76,000-acre total of producing trees needed on the Ford plantations will therefore require the presence of approximately 11,000 tappers alone. These men will gather from 14 to 20 pounds of latex a day and will be paid a minimum of $.46 a day.

11. The steps in the preparation and shipment of the latex depend on the form in which the crude rubber is to be shipped. Crude is processed into crepe, smoked sheet, centrifuged latex, latex, or creamed latex. To date, most of the rubber from the Tapajos plantations has been shipped as creamed latex, with a dry rubber content of at least 60 per cent. Latex directly from the tree contains about 70 per cent water, but

when it is creamed with the seeds of *Dialium devaricatum*, a native product, the water content is reduced by about 30 per cent. The Ford plantations grow their own creaming agent.

FUTURE OF FORDLANDIA AND BELTERRA

The future of the two Ford plantations on the Tapajos River depends in large measure on the labor supply which is made available. If the company can find no more workers than are presently engaged, activities may have to be limited to approximately the area now planted. Should some new reservoir of satisfactory labor be found, either in Brazil or abroad, there is sufficient land meeting the minimum soil, relief, and climatic requirements of rubber, and enough capital ready for investment to insure the success of the project.

The Ford experiment has proved that plantation rubber can be produced in Amazonia. Future estimates are undependable, but figured on all present conditions, company plans call for an annual production of 6,000 to 7,000 tons of rubber by 1948. Experience gained at Fordlandia and Belterra should help future plantation operators to avoid some of the difficulties to rubber planting in the tropical Americas. It is doubtful, however, that Amazonia will be able to supply the entire crude rubber needs of the United States.

PART-TIME FARMING AND RECREATIONAL LAND USE IN NEW ENGLAND

Roland B. Greeley

A DISCUSSION of the significance of recreation as a source of income in rural New England, would, no doubt, tend to overemphasize the part it plays. An inventory of full-time recreational jobs would reveal that they are very few, but that there are tens of thousands of part-time jobs, which, if expressed in terms of man-years, or in terms of dollar-income, would amount to a very small percentage, say 3 or 5 per cent of the total man-hours of employment among rural people. This small percentage of employment, plus other benefits from recreation, manifested principally through the taxes and retail trade, is of great significance because it means the difference between red ink and black on the ledgers of thousands of New England farmers and hundreds of New England towns. Trustworthy data and statistics on the subject are, and have been, inadequate for definite conclusions.

Although there are many exceptions, in general the factor that makes the difference between the marginal and the sub-marginal farm areas in New England is the presence or absence of sources of income to supplement that income received from cash crops. Hence, although recreation or any other source of supplementary income may in itself account for a relatively small part of the total, it may nevertheless be the determining factor in the entire economy of the area.

If a man's income is 5 per cent more than his expenses, he is well off; if it is 5 per cent less, he is poor. Probably the income from sale of agricultural products averages less than the total family expenses on at least half the farms in New England. Yet the proportion of farm families that do not manage to make both ends meet nowhere approaches 50 per cent.

Supplemental sources of income can be divided roughly into four categories. The first is produce for home consumption. Despite the fact that this does not actually bring in money, it is nevertheless significant as a source of real income because of the cash outlay which it saves. Judging by such census returns as are now available, at least 10 per cent of New England products, by value, were consumed on the farm. This was the equivalent of about $200 of income on the average farm. Historically, subsistence farming was the principal factor in all New England agriculture, but during the past century its importance has declined rapidly until, in the recent past, it has not received the emphasis it should. Primarily under the wing of the Farm Security Administration emphasis on production for home consumption is again being stressed in rural New England. The result should be an appreciable rise in the farmer's real income.

A second type of supplemental farm income accrues from the sale of forest products. Those products used on the farm account for an appreciable item of real income, but the woodland products sold for cash are also significant—account for an average of 5 per cent and in some sections for as much as 10 per cent of all farm income.

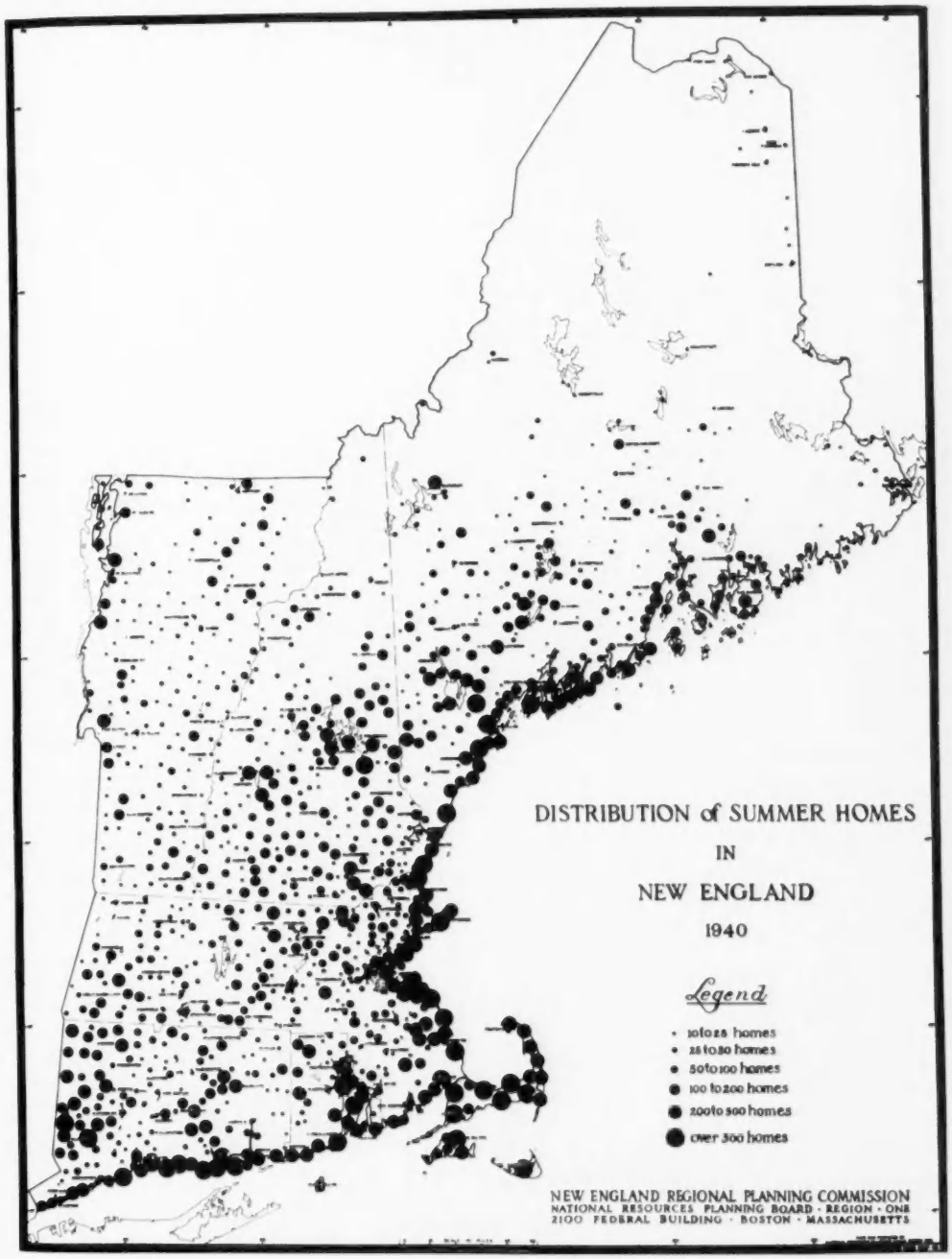


FIGURE 1.—The 130,000 summer homes scattered throughout New England play a significant part in the rural economy as well as the local tax rate of most New England towns. The dominant attraction and advantage of coastal location, and its modification by proximity to dense urban populations or the facility and adequacy of transportation is clearly revealed in the distribution of larger dots; that mountains and lakes are not nearly so desirable or so attractive as the sea is obvious. Distance from dense population centers, and inadequate highways and facilities for comfort and entertainment, have barred eastern Maine and northern Maine and New Hampshire from appreciable local and direct benefits of the recreation industry.

Third of the four types of supplemental farm income is the income received from manufacturing and other urban types of employment. This is perhaps the largest of the four categories, although there is no way of determining exactly what is its scope. Except in Aroostook County all farms in New England are within relatively easy commuting distance of industrial communities; even in the predominantly rural state of Vermont almost no farmers live more than fifteen miles from a town in which two hundred or more industrial workers are employed.

Census reports indicate that 42 per cent of all New England farmers received some off-farm employment during 1939, and the average of those farmers worked more than half-time on non-agricultural work. Much of this work was undoubtedly public work—on the roads, driving school buses, and similar jobs; but probably the major portion, especially of those who had 100 days or more of off-farm work, was in industrial or commercial employment. Particularly significant is the fact that farm operators in New England worked for pay in non-farm jobs an equivalent of nearly 70 days apiece during the year 1939, a not unusual year. This is much higher than in any other section of the country, the next highest region being the Pacific Coast, where the average was less than 60 days per man. This is about as striking testimony as could be obtained to the intimate relation that exists between agriculture and industry in New England.

The fourth category of part-time farm income is that resulting from the recreation business, widely advertised as New England's second largest industry. That the value of recreation exceeds that of agriculture in New England is due to the volume of urban recreation—movies, theaters, sports events, dance halls, and the like—and to the amount of money spent on presumably recreational travel. But even if these portions of the total recreation income are discounted, that part of the recreation business which brings direct returns in rural New England is still very nearly as great as the income from farm production. Chief benefits to farm communities are in taxes, in part-time employment, and in the money spent by recreationists for normal community services.

No region-wide or even state-wide studies of the actual import of this recreation business have been made, but there are several sample studies or partial indices that give a fair impression of its significance. Nearly ten years ago, Dr. David Rozman, wrote a paper on the "Recreational and Forestry Uses of Land in Massachusetts." Many of the facts which he presented at that time are still essentially true today, and some of his conclusions are as significant now as they were in 1932, if not more so. A few of these conclusions are quoted, as follows:

"The development of recreational uses in communities with a large area of idle land benefits the local population by providing a greater amount in tax receipts, a local market for agricultural products, and some employment for the local people. The negative effect in some cases is found in lack of interest in local institutions and occasional competition with the farmers for hired labor.

"In many towns there are exceptional opportunities for the development of recreational uses of land, and while the number of summer homes in these areas are increasing it is not commensurate with the amount of land available.

"Although the indications are that with a further development of good roads a considerable amount of the present area of idle land will be taken up in the near future for part-time

farming, recreational and residential uses, the major part of it has to be utilized for the growth of trees.

"In planning further acquisition of land by the State and other public institutions for forestry or recreational purposes, it is advisable to exercise more care not to include towns where the improvement of present roads and the construction of new highways is likely to create in the near future a considerable development of part-time farming and summer homes."

A short while later a study of "Recreational Uses of Land in Connecticut" was carried on by two sociologists at the Connecticut State College, Whetten and Rapport. This report presented rather detailed analyses of the proportion of total land and of assessed valuation which was devoted to recreational use. It revealed that 13 per cent of the area of the state was in some sort of recreational use (this, however, included the area of all state park and forest lands); that the assessed value of summer homes amounted to 4 per cent of the total property value of the state; and that for 40 per cent of the rural towns in the state summer homes account for from 15 per cent to as high as 59 per cent of the grand list. In this report, as in Dr. Rozman's, the writers emphasized the importance of relating agricultural land use planning, and especially the planning of sub-marginal land uses to recreation. Three sentences from the Connecticut report follow:

"The trend in the utilization of agricultural land will tend to facilitate the transition of sub-marginal land to recreational uses. . . . It seems very probable that the recreational uses of land in Connecticut will become increasingly important in the future. . . . Since 63.6 per cent of the total area of recreational land is devoted to summer homes and lots, it might be expedient to consider carefully whether it is advisable for the state, or the towns, to purchase the desirable locations, as they become available for public use."

Had studies similar to these been made in the other New England states, or more recently in these two states, they would certainly have brought out the same basic results and led to roughly the same conclusions: that summer homes and related recreational activities account for a significant portion of rural tax values; that this type of recreational use is particularly valuable as a means of facilitating the removal of sub-marginal land from agriculture; and that land use and other forms of planning should take due consideration of potential non-public recreational uses of land.

A dramatic illustration of this point was presented by ex-Governor Aiken of Vermont at a regional planning conference a year and a half ago. He described an area in southeastern Vermont where cursory surveys had indicated the desirability of retiring a sub-marginal area, including nine farms, from private ownership. Objectors succeeded in retaining the area in private ownership, despite threats that the town tax rate would suffer from the cost of servicing out-of-the-way and probably tax delinquent farms. Five years later one of the properties was still being farmed, and paying taxes; the other eight had been bought and improved as summer homes and were bringing in more taxes from out-of-state-owners than they had ever paid as farms.

This is not uncommon, nor is its scope confined to a relatively few areas particularly well suited to summer home use. There are, in the region, 130,000 summer homes, a number equivalent to 15 per cent of the total number of dwellings in places of less than 10,000 people. Each of more than 300 munic-

ipalities has at least 100 summer homes; and in another 500 there are from 25 to 100 vacation dwellings; thus in half the towns in New England there are at least 25 summer homes. Other indices of the volume and distribution of recreational activities are the facts that there are, in New England summer homes and commercial overnight establishments, accommodations for at least a million people; that 250 towns have more than enough recreational accommodations to house their entire populations; and that in 75 per cent of all towns and cities in the region, the capacity of commercial establishments and summer homes amounts to more than a hundred persons.

The importance of recreation as a source of part-time employment is much more difficult to demonstrate by reference to statistics than is its importance as a substantial factor in the tax base. However, it is obvious that 130,000 summer homes and lots cannot be maintained and serviced except through the employment of thousands of carpenters, plumbers, gardeners, and other workmen. Similarly, the tourist homes, inns, and tearooms constitute a large source of part-time or even full-time employment for local residents as well as college students and others from the city. But of almost as great significance are the volumes of recreation patronage received by retail trade outlets. Hundreds of country stores, filling stations, and amusement centers, boons to the year-round residents, could not possibly break even, much less show a profit, if it were not for the summer trade. As was the case with the farmers who were able to come out "in the black" only because of their off-farm work, so with the proprietors of countless rural business establishments. Recreation sales are essential if they are to keep going.

POST-DEFENSE READJUSTMENTS

It seems inevitable that, in New England at least, post-defense readjustments will reveal a very definite tendency towards decentralization, a movement from centers of defense industry to rural areas, a back-to-the-land movement of great magnitude. During the thirties a marked reduction in industrial employment brought about a decided increase in the number of rural residents. From 1930 to 1940 there was an increase of 8 per cent in the number of farms in New England, while the country as a whole was experiencing a decrease. But at the same time the acreage of farm land in New England was decreasing: the increase in the number of farms resulted directly from the back-to-the-land movement; the decrease in farm area indicates that the process of abandoning sub-marginal farm land was continuing even while new small farm units were being opened up. Population figures show clearly the same trend toward decentralization. For the first time in many decades the rate of increase of the three northern New England states, predominantly rural, exceeded that of the three southern, or industrial ones; two-thirds of the total population increase was accounted for in places of less than 10,000 people; nearly a third of the places of more than 10,000 people lost in population during the depression; and more than 400 which had lost in population between 1880 and 1930 again showed a positive rate of increase during the past decade.

The present industrial boom has completely reversed this trend, and has brought a strong migration to industrial centers. If estimates of population increases at defense centers are reliable, then the population of rural New England must have fallen off very

nearly 10 per cent in the past two years. Actually this figure underestimates rather than overestimates the total effect of the defense impact upon rural New England when the draft and the practice of commuting from rural areas to defense centers are taken into consideration. We all know that the present situation is temporary; and many of us feel that, despite efforts which will be made to convert the defense productive effort into lasting peace-time production, there will be a marked lay-off of industrial workers as soon as defense activity slackens.

The inevitable result will be a repetition of the back-to-the-farm movement that occurred during the thirties. One of the first steps in planning for such a movement is to work out means of guiding people to good farm land, to prevent them from trying to work poor land, incapable of being farmed profitably. Rural zoning is often suggested as a means of accomplishing it. This would seem to be a particularly opportune time for adopting rural zoning because defense industry has brought about so much removal of people from sub-marginal lands, and because there will soon be a definite tendency for unemployed city-dwellers to take up these or other lands which would be zoned against agriculture.

The next step is to evolve ways of providing part-time employment, or other supplementary sources of income for these refugees from the city. Silviculture presents one important opportunity for doing this; however, the immediate returns will not be sufficient to help much unless we inaugurate some way of subsidizing those engaged in forest cultivation until they have been able to harvest a paying crop.

Partial subsistence farming will offer another way of keeping the wolf from the door. But this, at best, will provide a mere existence rather than a decent living, and hence should be relied on to mitigate but not to solve the problem.

Part-time employment in industry as a source of supplemental income, has in the past been the chief source of such off-farm employment, and may continue to be. It seems rather clear that the future economic security of much of rural New England, with its 200,000 industrial wage earners in places of less than 10,000 people, will depend to a marked extent on the future stability of small, scattered industries. Nevertheless, it will not pay to depend too strongly upon these industries as sources of part-time rural employment during the readjustment period, because, even if these industries do survive, they cannot be expected to expand or probably even to maintain their present employment levels.

Recreation remains the chief source of income. Here also it is conjectural as to whether opportunities will expand much during a depression period. During the last depression it appears that the volume and extent of recreation business came pretty close to holding its own, and its relative position was way ahead of most types of economic activity. It seems reasonably safe to assume that this same situation will prevail in the near future. Certainly the increased mobility, the emphasis on travel, the desire to turn productive effort into the manufacturing of automobiles and private airplanes, will favor increased recreation activity. Periods of leisure, enforced or otherwise, suddenly available to those who have been working under heavy strain at good wages will also help. All in all, recreation appears to offer more opportunities for supplemental sources of rural income than either of the other three types we have discussed. If this is so, the development of recreational facilities

in planning to meet post-defense problems should be emphasized.

Highway and other transportation facilities must be designed to accommodate the needs of recreational traffic, and to attract recreation business. This means not only the construction of new high-speed access highways but also the improvement of existing roads in such a way that the recreation business will be distributed throughout the areas where it is needed. Provision must be made not only for first-class highways over which visitors may get into the recreation areas of New England, but also for good, attractive roads from which they may enjoy the area which they have come to see.

Land use plans must be adjusted to provide for greater development of recreational potentialities. Rural zoning and other, more positive measures must be put into effect in such a way that recreational uses are encouraged at the same time that agricultural uses are being improved. Educational programs designed to help farmers improve their farm practices must be supplemented by programs which will show these same farmers how to capitalize on their recreation assets. They must be made to realize that rural farm scenery is one of New England's greatest attractions; that unspoiled farm scenes are in many ways more important recreationally than historic monuments; that those details of the farm and village scene which appear to them to be outmoded relics of an era long past may be their most valuable assets; and that unused, juniper-choked pasture is far more interesting to the vacationist than well-managed woodland, although this does not imply that white pine and hardwood saplings should be stripped from all abandoned pastures.

New England, especially rural New England, has an extremely complex land use pattern. The rural economy is dependent to a great extent on the inter-relationships which exist among the various types of land use. Hence it is particularly important that land use planning take full cognizance of these inter-relationships. Only if this is done, only if those people engaged in agriculture take full advantage of the many opportunities for developing supplemental sources of income, can we be sure that rural New England will weather successfully the post-defense readjustment period.

LOCALIZATION OF SUMATRA'S OIL PALM INDUSTRY

George F. Deasy

GROWTH of the oil palm industry in Sumatra during the last two decades has bordered on the phenomenal. Production of palm oil in that island has increased from a few thousand metric tons in the early twenties of this century to almost two hundred thousand metric tons in 1937. In 1920, Sumatra accounted for less than one-half of one per cent of the world's annual export of palm oil; by 1937 over 40 per cent of the total export of that commodity was originating in the island (Figure 1). From an insignificant crop with an output far below that of most other Sumatran estate crops in 1920, the oil palm by 1937 had risen to a position of joint supremacy with rubber in the agricultural economy of the island.

Concentration of the Industry along the Northeast Coast

It is a relatively well-known fact that the oil palm industry of Sumatra is not widely diffused. Instead, it is strikingly localized within a fractional area in the northeastern part of the island. Of the 203,498 acres (this and the immediately following figures are for 1937) of plantation land devoted to the palm tree in Sumatra, over 80 per cent (165,764 acres) is found in this elongated coastal strip (Figure 2). Here, in the so-called North Sumatra oil palm region, 45 of the 52 palm-growing plantations of the island have been established.

As has been stated, this concentration of the oil palm industry in Sumatra is common knowledge. What are not so well known are the factors that have operated to confine the industry to such a restricted segment of the island. In fact, to the author's knowledge, no reasoned explanation for this situation has been published in any treatise that is available in this country. A list of certain advantages offered by the Sumatra East Coast "for the establishment of plantations for producing tropical products, such as palm oil, rubber, wrapper tobacco, fiber, etc." was presented by Sydney B. Redecker in "Palm-Oil Industry of Sumatra and West Africa" (U. S. Department of Commerce, Trade Information Bulletin No. 471, 1927, p. 5), but this list is far from constituting a geographical analysis of the localization of the industry. It is, therefore, the purpose of this brief article to make intelligible the distribution of the oil palm industry in Sumatra. It is further intended to indicate, on the basis of present distribution, the various potential areas of future expansion in the industry and the relative likelihood of each such area to expand under the stimulus of increased world demands for oil palm products.

Factors Involved in the Localization of the Industry

The present general distribution of oil palms in Sumatra is in response to four factors: altitude and relief, drainage, accessibility, and rainfall. All of these factors are not of equal importance. Each will be examined in turn in order to indicate the influence it has exerted in localizing the industry.

Successful oil palm cultivation cannot be attained in areas of high altitude or rugged relief. Appreciable altitudes

(above a few thousand feet) experience temperatures unsuited to the tropical palm. Excessive relief, whether at high or low altitudes, results in too rapid drainage of soil moisture and early loss of soil cover in the torrential tropical showers, unless resort is had to inordinately expensive preventive measures such as terracing. Consequently, the large attenuated strip of mountain, plateau, and rugged hill lands of western Sumatra is unsuitable

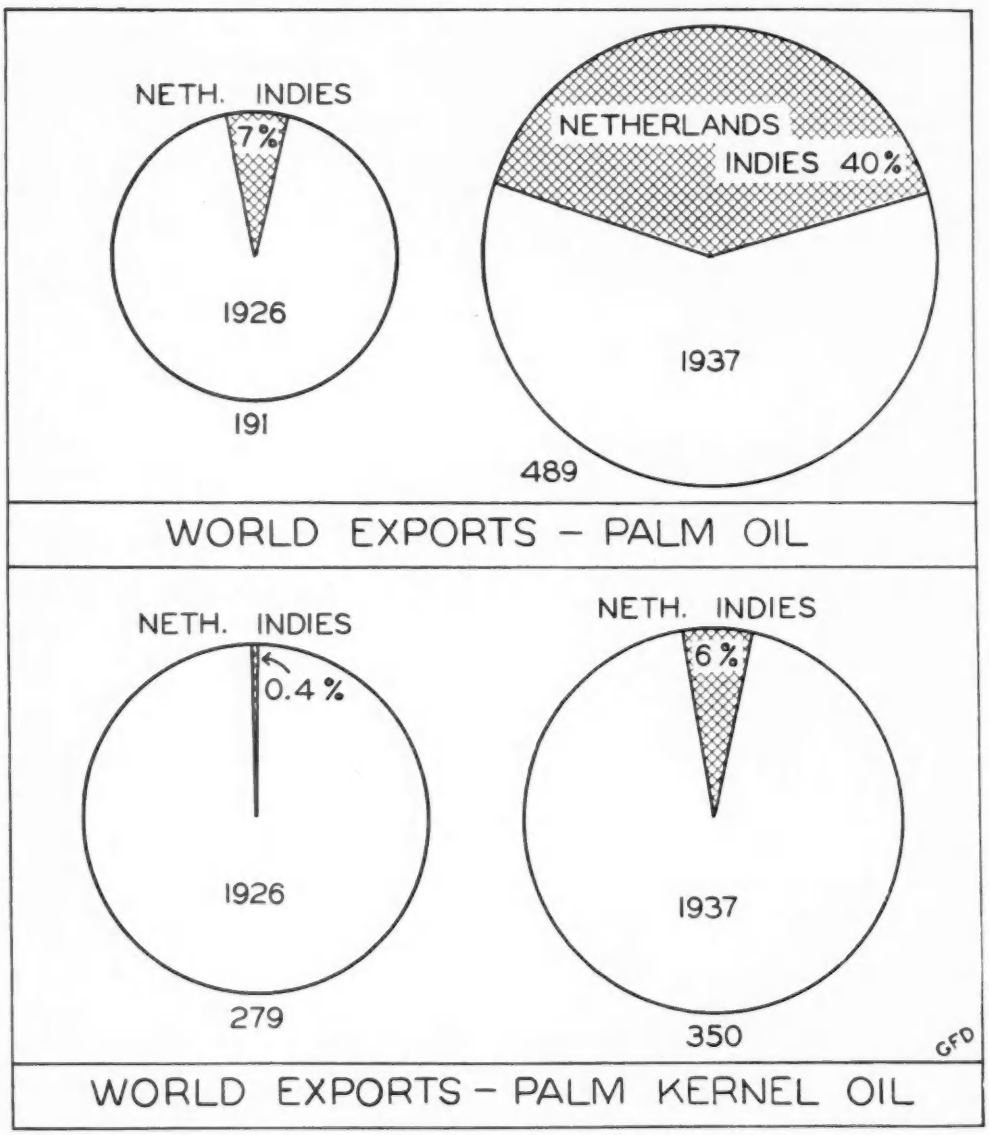


FIGURE 1.—The volume of each circle is proportional to the total annual world export of palm oil or palm kernel oil from primary producing countries (actually the palm kernels are exported, but for purposes of comparison these exports have been expressed in terms of oil-content of the kernels). Figures outside the circles represent total world exports of palm oil and palm kernel oil, in thousands of metric tons, for the respective years. The shaded segments of the circle, and the percentage figures therein, represent the share of the Netherlands Indies in this trade. Since over 99 per cent of the Netherlands Indies exports of palm oil and palm kernels come from Sumatra, these diagrams actually indicate Sumatra's share in the trade.

for oil palm production and the industry has never spread to that region (Figure 2).

While the oil palm is highly tolerant of a great variety of soil conditions, it does not grow in areas of poorly-drained swamp and marshland. Examination of the root systems of normal mature trees has shown that some of the roots penetrate the soil to a depth of between eight and ten feet. (See material on the soil requirements of the oil palm in B. Bunting and others, "The Oil Palm in Malaya," Federated Malay States, Department of Agriculture Bulletin, Kuala Lumpur, 1934.) Such root development is impossible with a high water-table. Consequently, most of the coastal margins of the plains areas, where the only adequately drained portions are the natural levees bordering the larger streams, are unsuitable for oil palm cultivation and have not been used.

There remain only the intermediate, somewhat higher, older, more rolling lands of the inner margins of the eastern and western plains. These areas (a kind of piedmont) possess a topographic and hydrologic complex that is adaptable to the palm. The most extensive tract of such suitable land borders the inner margin of the broad eastern plain. From its position on the island this might be designated the "medial strip" (Figure 2). It is on this "medial strip" that most of the oil palm acreage of Sumatra is located.

Among the various parts of this "medial strip," only the two terminal segments possess the further advantage of easy access to tidewater. The remaining portions are isolated from the ocean by broad zones of mountains or marshland, both of which are difficult and costly to traverse. The northern terminal segment, adjacent to the extensively traveled Malacca Straits, was the first of the two termini to receive

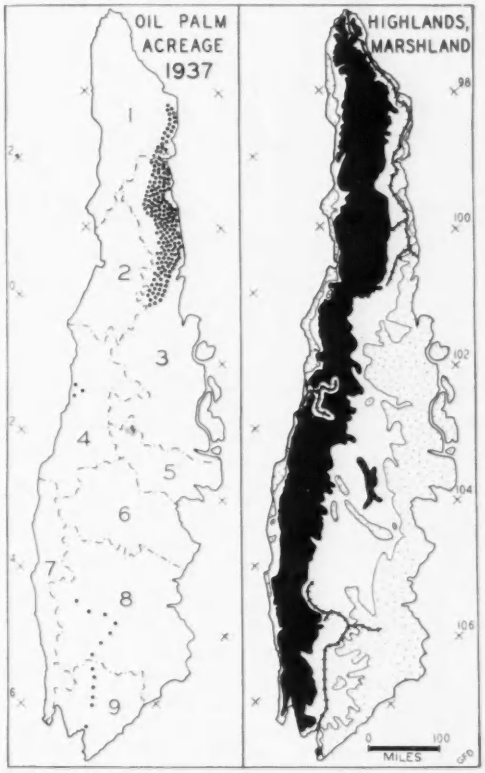


FIGURE 2.—Oil palm acreage of Sumatra, 1937. Each dot represents 1,000 acres of land planted to oil palm. The location of the dots approximates the actual distribution of palm acreage. A fractional part of the indicated acreage (about 15 per cent) consists of young, non-bearing palms. The figures refer to provinces, as follows: (1) Atjeh en Onderhoorigheden, (2) Tapanoeli, (3) Oostkust van Sumatra (Sumatra East Coast), (4) Sumatra Westkust, (5) Riouw en Onderhoorigheden, (6) Djambi, (7) Benkoelen, (8) Palembang, and (9) Lampoengsche Districten. Data for acreage distribution by provinces was obtained from the Department of Economic Affairs, Bulletin of the Central Bureau of Statistics No. 157, The Export Crops of the Netherlands Indies in 1937, Planted Area, Production and Export. Batavia, 1938. No later data were available at the date the map was constructed (1941).

Highlands and Marshlands of Sumatra. The highlands and marshlands were generalized from a large-scale Dutch map published in 1922, with certain modifications of the marshland areas being based upon the relief sheets of Sumatra in the "Atlas van Tropisch Nederland," 1938. The areas indicated as highlands are above 820 feet in elevation. High altitude or rugged relief are typical of most parts of these lands. The marshland areas are characterized by a water-table at or near the surface of the ground during the greater part of the year. Minor "islands" of dry land within the designated marshlands have been omitted. Railroads from "Atlas von Tropisch Nederland," 1938.

rail transportation. Several rail lines, serving other plantation crops, existed there years before the initial development of the Sumatran oil palm industry. It was along parts of these railroads that the new oil palm industry, with its need for cheap transportation, first developed in the decade 1910–1920. And it is along these same railroads, now connected and extended, that the bulk of the present oil palm acreage is located. This is the famous North Sumatra oil palm region.

During the last decade a counterpart rail line has appeared in the southern terminal segment of the "medial strip" (Figure 3). While the oil palm industry has shown some recent development here, this southern area has not yet been able to overcome the initial advantages accruing to the northern region due to its early start—advantages such as agricultural experiment establishments, planters' organizations, extensive storage facilities (in 1935, there were 35 storage tanks at Belawan-Deli, the principal port of shipment of palm oil in Sumatra, with a total capacity of approximately 17,500 metric tons of palm oil. Most of these tanks were owned jointly by the plantation companies. See "Netherlands Indian Palm Oil and Palm Kernel Production and Trade During 1935," Report of the American Consul, Medan, Sumatra, April 14, 1936), favorable shipping facilities and freight rates, and com-

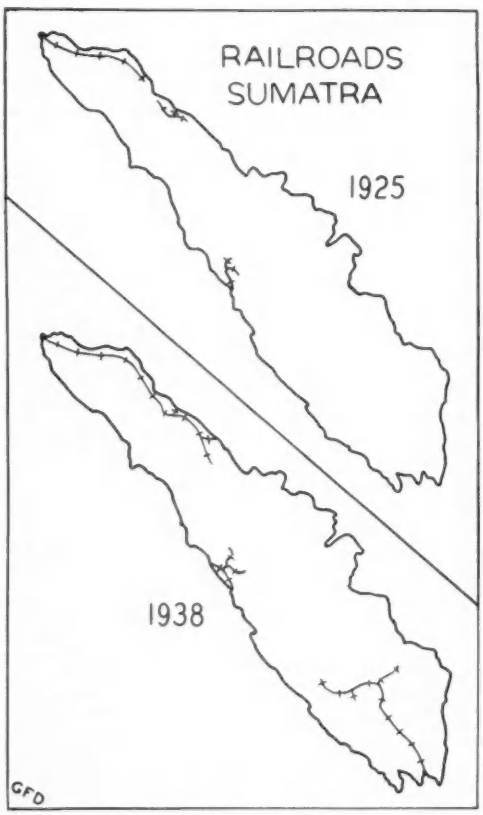


FIGURE 3.—The top map represents railroad conditions in Sumatra during the period when the oil palm industry was first developing there; the bottom map indicates the railroad situation as it exists today. (Sources: "Stielers Hand-Atlas," 1925; "Atlas van Tropisch Nederland," 1938.)

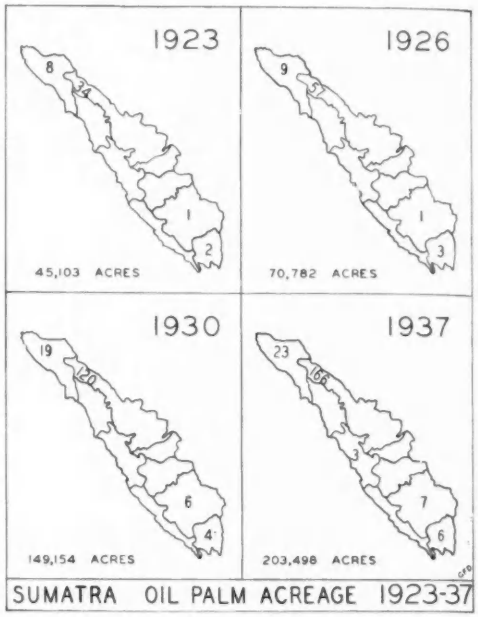


FIGURE 4.—The figures within the various provinces represent total oil-palm acreage, in thousands of acres, for the respective years. A fractional part of this acreage is non-bearing, since the palm fruits only after the fourth year. The names of the provinces are indicated in Figure 2. (Source of data: Various government publications of the Netherlands Indies, 1924 to 1938.)

mercial contacts in foreign countries. All of these factors have acted as powerful magnets to attract new estates to the North Sumatra oil palm region and to favor the expansion of acreage in that area rather than in the competing region in the south. Nevertheless, there has been a small but noticeable development of the oil palm industry of the southern region during the last fifteen years (Figure 4).

One additional feature of the distribution of oil palms in Sumatra needs explanation if the localization of the industry is to be adequately explained. It will be noticed (Figure 2) that the palm areas in the northern and southern extremities of the island do not extend the full length of the rail lines, despite the apparently favorable complex of environmental and location factors. An examination of the rainfall maps of Sumatra (Figure 5) provides a clue to this seemingly anomalous situation. Both the July and November rainfall maps show areas of relatively deficient precipitation in the extreme northeastern and southeastern parts of the island. These areas are less suitable for oil palm production than other available nearby regions, and consequently plantings have not been made there.

FUTURE AREAS OF EXTENSION

What can be said concerning the *future* localization of the oil palm industry of Sumatra? If world demands for palm oil continue to increase, and if Sumatran plantations can continue to compete successfully for this market against nearby Malayan plantations and the native and plantation production of West Africa, then it becomes fairly evident, from the foregoing discussion, where future expansion of the Sumatran oil palm industry will take place.

It is probable that the major part of the future growth will continue to occur in the northern district rather than in the southern district or the west coast district. This is not due to any inherent environmental advantages that the north possesses, but instead to that less tangible but powerful set of commercial and human factors that have operated during past decades to its advantage.

In the North Sumatra oil palm district two possibilities for growth exist: (1) an expansion in palm acreage in the general region already occupied by the palm, and

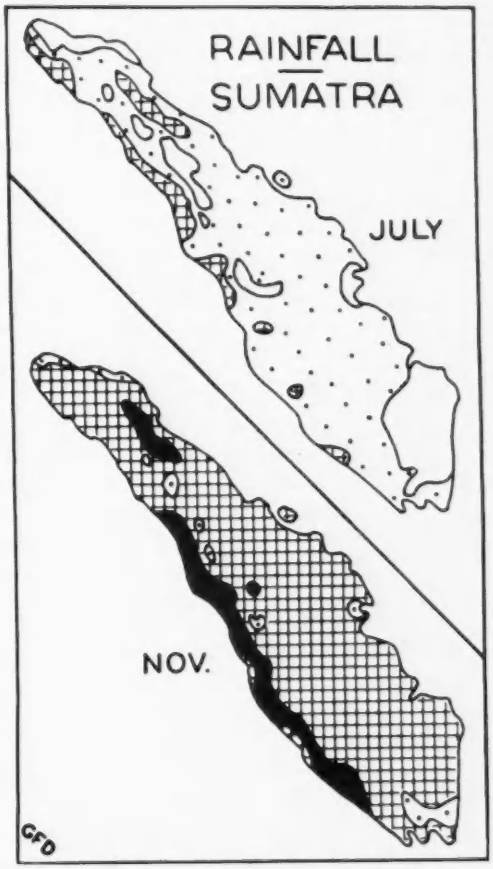


FIGURE 5.—Areas shaded solid black receive 400 to 600 mm. (16 to 24 inches) of rainfall for the month; the cross-ruled areas receive 200 to 400 mm. (8 to 16 inches); stippled areas receive 100 to 200 mm. (4 to 8 inches); areas left white receive less than 100 mm. (4 inches) for the month. (Source: Modified from maps in the "Atlas van Tropisch Nederland," 1938.)

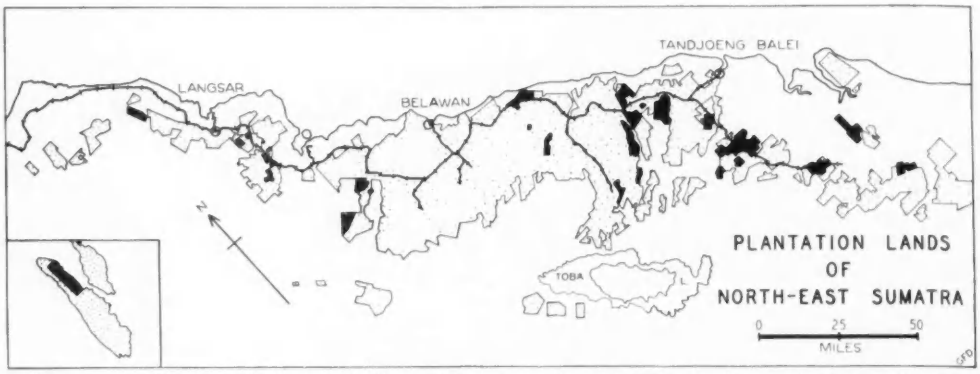


FIGURE 6.—The stippled areas indicate European plantation lands in northeastern Sumatra. The oil palm areas are shaded black. Each such blackened area may, and frequently does, indicate palm land belonging to more than one estate. Native crop lands and unplanted areas are left unshaded. Note the concentration of the plantation lands in the non-highland, non-marshland area (compare with Figure 2). Much of this territory, now occupied by other plantation crops such as rubber and tobacco, is environmentally adapted to the palm. (This map was modified from the large four-sheet map entitled "Cultuurgebied Oostkust van Sumatra" [1: 200,000], published by the major plantation association of the region, the Algemeene Vereeniging van Rubberplanters ter Oostkust van Sumatra [A.V.R.O.S.], in 1929. Palm acreage has increased considerably since that date.)

at the expense of other crops in the area (Figure 6), or (2) an extension of palm cultivation southward along the "medial strip" onto virgin lands, if and when rail lines advance into that territory. Obviously expansion northward into Atjeh along the already existing railroad is not feasible because of less favorable rainfall conditions. Likewise, the movement of palm cultivation westward onto virgin lands will be hindered by the topographic barrier. Eastward expansion will be stopped by drainage conditions.

Ranking second to the North Sumatra region in potentialities as a future center of palm production is the southern district. This region is apparently the environmental equal of the northern region. Only the handicap of a late start seems to be retarding its rapid expansion.

The west coast palm area is definitely limited in its future potentialities by lack of extensive land areas environmentally suited to the industry.

The vast areas of potential oil palm land in the interior portions of the "medial strip" have a favorable environmental complex but they are without adequate transportation facilities. Any development of the palm industry in this region is apparently a matter of the distant and unpredictable future.

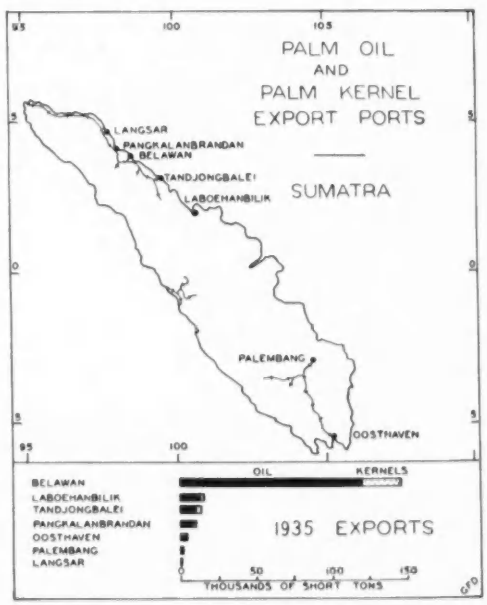


FIGURE 7.—Belawan, with its unequaled palm oil storage and shipping facilities is by far the outstanding port of Sumatra for that commodity. (Source: "Netherland Indian Palm Oil and Palm Kernel Production and Trade During 1935." Report of the American Consul, Medan, Sumatra, April 14, 1936.)

WISCONSIN CRANBERRY INDUSTRY

Loyal Durand, Jr.

THE American cranberry crop of some three-quarters of a million barrels is produced mainly in five states: Massachusetts, Wisconsin, New Jersey, Washington, and Oregon. This marshland crop, grown in "cranberry bogs," and harvested in the early autumn, constitutes an important product for the Thanksgiving and Christmas markets. American custom almost universally dictates the use of cranberries on the tables of the nation during the holiday season. Prices of cranberries are uniformly good in most years; supply is limited by the generally small producing areas. Berries are shipped all over the United States, it not being unusual for the Wisconsin crop to find markets in the East Coast cities, while Massachusetts berries are often the only ones offered for sale in Wisconsin or midwestern cities. Sale of the yearly cranberry crop is generally consummated during a few weeks of the year, after which the berries disappear from the American grocery store, to reappear again only following the harvest of the succeeding year.

The 1941 cranberry harvest consisted of a crop of 749,200 barrels, distributed among producing regions as follows:

Region	*Barrels*
Massachusetts	510,000
Wisconsin	105,000
New Jersey	88,000
Washington	36,000
Oregon	10,200

The average production of the past ten years has seen New Jersey in second position among American cranberry producing states. The Wisconsin production has passed New Jersey in recent years, and available evidence indicates that the acreage of Wisconsin cranberry bogs is being extended considerably, a factor which may entrench Wisconsin in second position (Figure 1). Between 1940 and 1941 the Wisconsin producing acreage increased from 2,500 to 2,800 acres, principally as a result of new cranberry plantings in new producing areas of the northwestern part of the state. Output of cranberries fluctuates widely from year to year, the result chiefly of unfavorable weather conditions at or just before harvest time. In 1940 Wisconsin produced 121,000 barrels of the national total of 580,300, or about 20 per cent, whereas the 1941

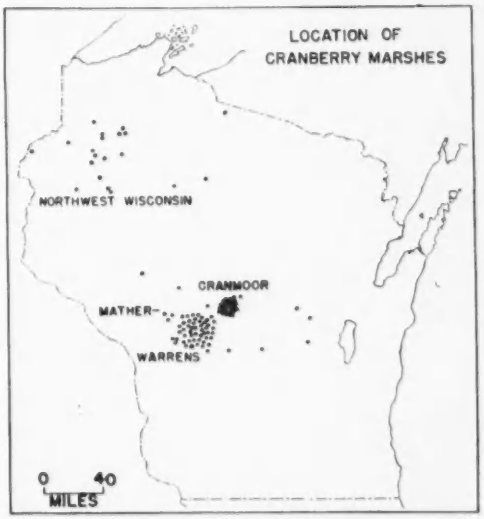


FIGURE 1.—Though cranberry bogs are scattered casually over a considerable area of Wisconsin, commercial production of the berries is concentrated within two major sections, the Cranmoor district and the Mather-Warrens district, both on the bed of former glacial Lake Wisconsin. Since 1910 production has increased in northwestern Wisconsin, now a third but still relatively minor producing district of significant production.

crop constituted 14 per cent of the nation's total.

HISTORICAL BACKGROUND OF THE WISCONSIN CRANBERRY INDUSTRY

Wild cranberries were native to the marshlands of central Wisconsin. Early settlers harvested them each autumn; the Indians had long utilized them, and had put them to a variety of uses. The year 1853 is the year of earliest known record of cranberry cultivation in the state; yet "cultivation" at the time meant little more than a few cursory improvements of native marshes, principally some ditching to provide both a means of flooding the bogs as well as the drainage of excess water from them. Some effort was undoubtedly devoted to weed control. However, marshes were not planted to cranberries and cultivated as at present, but were merely improved to a condition beyond their native state. Records indicate that cuttings from cranberry vines were planted, though, at a relatively early, but unknown, date. Commercial culture of native cranberries was well established on the marshlands of southeastern Waushara County (north of Berlin in Green Lake County) in the late 1850's and 1860's. Profitable crops of wild cranberries were harvested in 1868 and 1872, the later year seeing a price of $11.00 a barrel. The profitable years of the early 1870's were undoubtedly of tremendous importance in the establishment of additional cranberry marshes in Wisconsin.

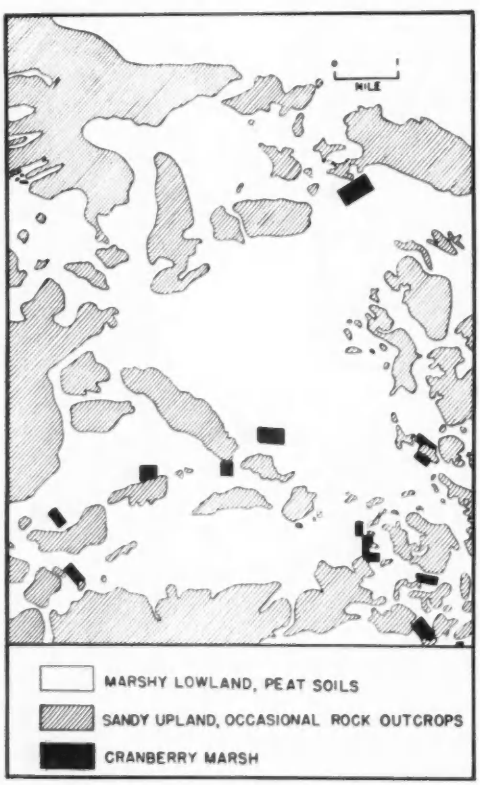


FIGURE 2.—Part of the bed of former glacial Lake Wisconsin in eastern Jackson County, showing the combination of sandy "islands" and extensive peat marshes. The cranberry bogs are in the Mather-Warrens region.

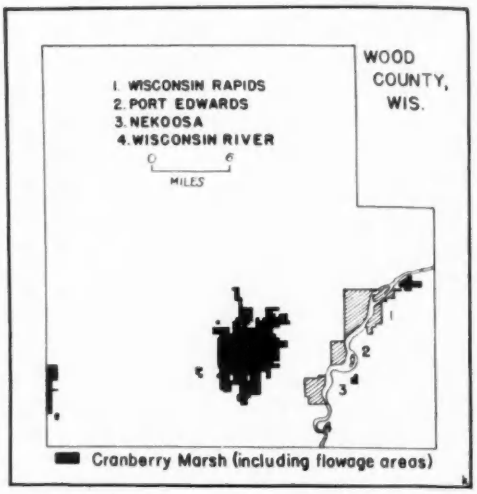


FIGURE 3.—The nearly continuous cranberry marsh and cranberry flowage area in the Cranmoor district. Cranberry growers were instrumental in having the town (township) of Cranmoor formed, and most of the residents of the township are engaged in the cranberry industry.

The greatest cranberry development took place, not in the Berlin area, but on the large marshlands in central Wisconsin. The central Wisconsin marshland areas occur over wide sections of the bed of former Glacial Lake Wisconsin, a marginal lake dammed in as a result of

ice blockage of the Wisconsin River. The present landscape of the former lake bed consists of extensive areas of sand and peat land—sandy islands too infertile or too dry for successful cultivation, and ill-drained natural lowlands too damp for agriculture (Figure 2). One element of the landscape lacks abundant soil moisture; adjacent areas have too much for general farming. Cranberries were native to the Lake Wisconsin marshlands as well as to areas farther east; Indian tribes annually made encampments in the section to harvest cranberries from the extensive peaty swales.

Cultivation of cranberries in the Cranmoor district of southern Wood County, using "cultivation" in the same sense as previously, developed in the 1870's and 1880's. The high prices for cranberries that were paid in the Berlin area were received also in the Cranmoor section. Records indicate some phenomenal yields of wild cranberries in the region. However, most of the settlers of the sand-swamp area of the Central Sand Plain of Wisconsin were interested in general farming; many failed to succeed in that occupation and tax delinquency appeared in the region, even before the turn to the present century. In the 1890's much of the present cranberry land in the Wisconsin Rapids–Cranmoor district could be purchased for back taxes; after development some of it was valued at $500 an acre.

The cranberry marsh development of central Wisconsin has occurred in two separate locations, though both are on the bed of former Glacial Lake Wisconsin: (1) a nearly continuous cranberry bog and cranberry flowage land acreage in southern Wood County, southwest of the city of Wisconsin Rapids (Figure 3), and (2) a more scattered development in a single area embracing the eastern part of Jackson County, northeastern Monroe, and northwestern Juneau (Figures 2 and 4). The first-named area is the Cranmoor district, the second the Mather-Warrens district; the names are derived from three small shipping stations. The cranberry bogs on the bed of Glacial Lake Wisconsin have made the region the leading producing section of the state. The city of Wisconsin Rapids is the center of marketing and of the Cranberry Growers Association.

FIGURE 4.—Pattern of cranberry bogs in the Mather-Warrens region of the central Wisconsin sand plain. Note the relationship to small streams. This pattern differs from that of the Cranmoor section, and from that in eastern Jackson County as shown in Figure 2.

The central Wisconsin cranberry development came about partly as the result of individual initiative. Early harvesters of wild cranberries were not organized; such water as was needed for flowage purposes was obtained by each grower without thought of his neighbor. Problems of ditching, drainage, disease, insect pests were met individually. Judge J. A. Gaynor of

FIGURE 5.—The oldest commercial cranberry area of Wisconsin, now represented by one producing marsh. Old and abandoned cranberry areas may be seen on the airplane photograph, especially just to the north of the present marsh.

FIGURE 6.—Developed cranberry bog next to wild native marshland at Cranberry Lake. (Photo by Wisconsin Department of Agriculture.)

Wisconsin Rapids met these problems, first as a lawyer who worked on the legal aspects of drainage and water rights; later, as a member of the state legislature, the Judge obtained the first state appropriation ($250) in 1893 for cranberry studies. Following the 1893 act he was instrumental in arranging for a branch station of the Agricultural Experiment Station of the University of Wisconsin. This branch, devoted exclusively to the problems of cranberry growers, was established at Cranmoor in 1903, and was originally placed on the Gaynor marsh. The Experiment Station was in itself a "magnet" for further plantings of commercial cranberry bogs in the vicinity. Since 1899, extension money of various sorts has been devoted to cranberry interests, originally at the instigation of Judge Gaynor, until at the present time the cranberry work is being performed both by workers at the Agricultural Experiment Station and at the Wisconsin State Department of Agriculture, although the Cranmoor branch experiment station has been discontinued for some twenty years. The State Department has maintained a cranberry specialist on its staff each summer season since 1926. The early "start" of the Wisconsin Rapids region, the energy of a few individuals and the continued development has culminated in an important state and national industry.

RECENT CHANGES IN CRANBERRY MARSH LOCATION

The Berlin region, the first "commercial" cranberry area of the state in time of development, has declined in importance. Only one commercial cranberry marsh remains (Figure 5). Through the years the bulk of the state's crop has been from the marshlands of central Wisconsin. However since 1910, new cranberry developments have been made in northern Wisconsin—particularly the northwestern portion of the state. The northern marshes have accounted for: (1) greatly increased production per acre in certain recent years, and (2) increased state acreage. Extension of cranberry acreage in northwestern Wisconsin is continuing at present (Figure 6), and has been responsible for the entrance of that section of the state into the national cranberry scene as well as for increased activity in the older cranberry districts. Increases of producing acreage have been located in all of the state's cranberry districts except the Berlin area.

CLIMATIC SETTING OF THE WISCONSIN CRANBERRY INDUSTRY

The Wisconsin cranberry marshes, whether in central or northwestern Wisconsin, are located in a climatic setting wherein there is danger of an early frost. Frost is experienced over

the marshes annually in May, occasionally in June, occasionally in August, and annually in September. The central Wisconsin area has about 140 days in the growing season, the northwestern section from 120 to 130. However, the season over the marshes is in reality shorter than that recorded for adjacent uplands, and shown on general maps. On August 8, 1904, the temperature fell to 29 degrees Fahrenheit at Mather. Frost is not unlikely during the last week of August, and is certain to occur early in September, at the height of the picking season.

Frost protection is maintained by flooding the marshes. Water from flowage areas or reservoirs is allowed to flow over the bogs with the advent of low temperatures, and is drained from them after the frost or frost-threat has disappeared. A consequence of the Wisconsin climatic setting (Köppen Dfb) is that each grower must have access to an adequate water supply, both for the normal operation of a cranberry marsh and as a protection against killing frost. Failure of the water supply, especially in the autumn, is a serious matter; variations in the annual yields of individual marshes and variations in the state's yield of cranberries have often been due to weather conditions that prevail in late

FIGURE 7.—Part of the extensive marshland of the Cranmoor district. The Searls cranberry farm is shown, and the isolated cranberry bogs to the south of the buildings are the native home of the "Searls Jumbo" cranberries. The farm buildings are located at the end of a stub road from the north. The east-west white line is the Green Bay and Western Railroad. Harvested berries from the cranberry bogs immediately east of the buildings are put on wheeled "trucks" and pushed along the railroad tracks to the farmstead. The cranberry bogs to the south are reached only by boat. A master ditch connects producing bog and farmstead. Traces of old cranberry fields, utilized in the days of native wild berries, may be seen.

August and September. All cranberry areas the country over need adequate water supplies, since water is important in the production processes; the Wisconsin growers, faced with hazards of early frost not commonly experienced in the other cranberry districts, need water supplies in addition for the very existence of their industry at harvest time.

The United States Weather Bureau, realizing the necessity for adequate frost warnings in the Wisconsin setting, conducted a "frost project" in the central portion of the state in 1906–1909. The findings of this research were summarized in Bulletin T of the Bureau, published in 1910. It was found that the central Wisconsin marshlands were likely to experience damaging frosts in August or September when the temperatures at the closest main Weather Bureau Station at La Crosse on the Mississippi River, fell no lower

FIGURE 8.—The riverine pattern of cranberry marshes in the western portion of the Mather-Warrens district. This photograph taken in late April, shows the "spring flood" on the cranberry fields, which consequently appear in black. The ditch embankments between the fields appear in white. Reservoirs, impounded by dams on the creeks, may be noted. A long dam also impounds surface drainage along part of the shallow-valley side.

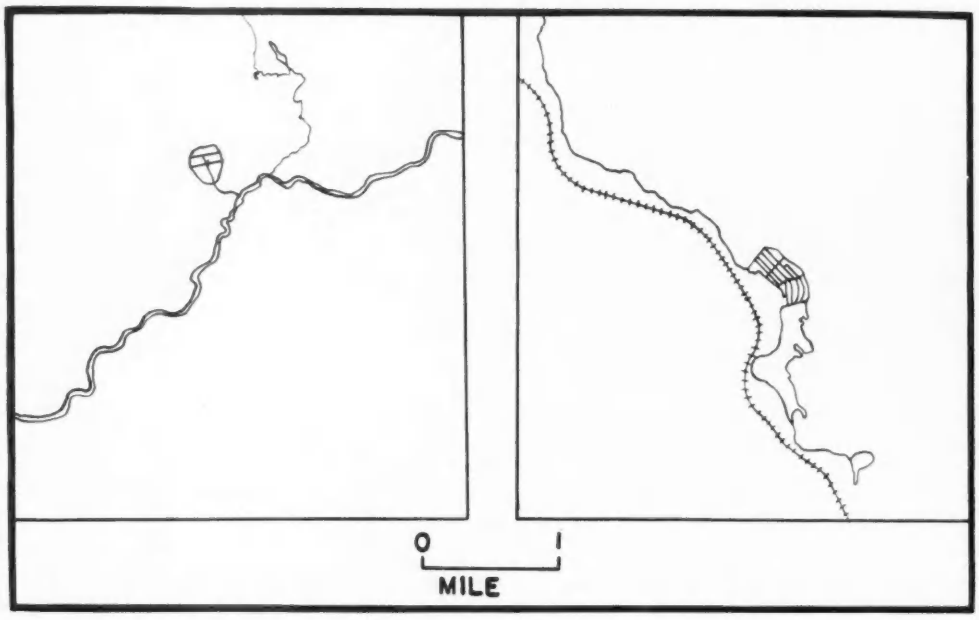


FIGURE 9.—Two examples of the isolated type of cranberry development in northwestern Wisconsin, both in Washburn County. One marsh is at the head of a small brook, the other obtains flooding water from the damming of a stream.

than 50 to 54 degrees F. A system of frost warnings for the growers was set up as a result of the research. The warning system has been vastly improved since developments of more modern methods of communication, and at the present time the existence of radio has greatly facilitated the widespread dissemination of frost warnings. Nevertheless, unseasonable weather still remains as a distinct hazard to the cranberry industry.

INDIVIDUAL CRANBERRY MARSH

The cranberry marsh in Wisconsin is today a carefully planted and cultivated area (Figure 7). Selected strains of cranberries are planted, and even the bogs which are devoted to "native vines" are carefully cared for. Disastrous peat fires in central Wisconsin in the dry years of the mid-1890's destroyed thousands of acres of natural cranberries. Restoral and replanting of the bogs resulted in careful management, planning, and control. Though "natives" were planted, the growers ceased major dependence upon acreages of wild cranberries, though there is some harvest of these berries even to the present. Improved species from the Cape Cod cranberry bogs were brought to Wisconsin. In addition some Wisconsin varieties were developed by the

FIGURE 10.—The Cranberry Lake cranberry bogs in Price County, northern Wisconsin. Water from the lake is used for flooding purposes. The water is then drained westward to the stream shown, although facilities are available for pumping it back to the lake if necessary.

FIGURE 11.—A new cranberry section, with leadgate to control water flow. Cranberry Lake. (Photograph by Wisconsin Department of Agriculture.)

growers, with the eventual result that both far eastern and Pacific northwestern growers now possess considerable acreages of Wisconsin-developed vines. Of the three varieties which are planted on most acres, the "Natives" and Searls Jumbo are Wisconsin strains, while the McFarlin is a Massachusetts product. A dozen or more additional varieties account for the rest of the Wisconsin acreage.

A cranberry marsh is a relatively compact area of twenty to one hundred acres (Figures 7 and 8). The actual shape of an individual marsh depends upon the contour of the surrounding higher land (if such is present). Each marsh depends upon a large surrounding area for its water supply and in central Wisconsin from five to seven acres of "flowage land" are needed for each acre of bearing cranberry vines (Figures 3 and 7). Thus a grower with 100 bearing acres must of necessity have a farm that is 600 to 700 acres or more in size. The region is consequently characterized by very large farm units, though but a small portion of the total unit is cultivated intensively. Where lakes or impounded reservoirs furnish the water supply, the ratio between cultivated and flowage area is not so great. Each individual development differs from others in detail, though all are distinctly dependent upon a large surrounding area for water supply. Several types of water sources are utilized; some growers, particularly in the Cranmoor district, use the catchment basin of their own marsh acreage, and the flowage area appears in the landscape as wild marshlands connected by ditches with the cultivated bogs (Figure 7). Streams are sources of flowage waters in other cranberry developments (Figures 8 and 9). Water from the Fox River and Willow Creek has been utilized in the easternmost bogs near Berlin. One or two very small streams supplement the natural marsh reservoirs in the Cranmoor section. Some of the marshes in the Mather-Warrens area are laid out on small swampy flood plains of the

FIGURE 12.—The spring flooding of a Wood County cranberry bog, a scene in late April. (Photograph by Wisconsin Department of Agriculture.)

FIGURE 13.—A rubber-tired duster in a cranberry marsh. Note the various warehouse buildings at the farmstead. (Photograph by Wisconsin Department of Agriculture.)

streams, and are served by water impounded by dams across the creek. Such reservoirs are small man-made lakes in the landscape; since the water depth in them is greater than in natural marsh flowage areas, the individual grower needs less total area for flowage purposes. The stream pattern of reservoir is most common throughout northwestern Wisconsin. Natural lakes in the glaciated north serve some marshes; the Cranberry Lake cranberry development in Price County utilizes lake water pumped from the lake to the adjacent bog (Figure 10). If water is low the bog is drained by re-pumping to the lake, thus conserving the water supply. Water is used by more than one grower on a stream development, where growers downstream may eventually use "drainage waters" from a cranberry marsh located farther up the watershed.

The cultivated cranberry marsh is threaded with ditches. It appears as a gridiron pattern from the air. The ditches are connected to the flowage lands at one side of the marsh and to a drainage area at the other side. Water may thus be led to or from the producing bog. The ditches must be kept relatively free from weeds to facilitate rapid flooding and drainage (Figure 11). Size of the producing section of the marsh between ditches differs, but is adjusted to the flooding needs and speed. In the Wisconsin climatic setting it is necessary to have facilities for speedy flooding with the approach of frost.

Water is needed by Wisconsin cranberry growers for purposes other than frost protection. All cranberry regions in the United States need water for the normal production of cranberries; it is in the additional abnormal need of water for frost protection that the

FIGURE 14.—Airplane dusting for cranberry leaf hopper in the Cranmoor district. (Photograph by Wisconsin Department of Agriculture.)

FIGURE 15.—Harvesting cranberries with the Wisconsin scoop, northwestern Wisconsin. (Photograph by Wisconsin Department of Agriculture.)

Wisconsin growers need access to large supplies. In the other uses of water Wisconsin cranberry districts are thus not abnormal.

Wisconsin cranberry bogs are flooded in the spring in order to kill insect pests, may be flooded several times during the autumn to ward off frosts, and are flooded in late fall, after the harvest season. This "winter flood" is permitted to remain on the bogs until spring, so that until the advent of a snow cover the bogs are in reality covered with a sheath of ice. Addition of sand to the bogs, a practice followed by some growers, is made by spreading the sand over the ice covering, and thus allowing it to sink among the cranberry vines following the spring thaw. In the spring the "winter flood" is withdrawn from the cranberry sections for a period of two to three weeks before the "spring flood" is allowed to spread over the fields. At this time all water is removed, and the field of cranberries has commenced a vigorous growth. By June the vines are in bloom. During the summer various spraying and dusting operations are carried on and the grower wages a constant fight against insect pests and weeds. Some varieties of weeds are especially undesirable, while others are not harmful and are not fought so intensively, so that a producing cranberry bog often has a weedy appearance.

Dusting is by wide-tired light vehicles, such as motorcycles (Figure 13), by low flying airplanes (Figure 14), or by walking through the bogs. It is generally impossible to drive any heavy machinery upon the cranberry fields. It is for this reason that as many operations as possible, such as sanding, are performed on the ice cover.

HARVEST PROBLEMS

The labor demand on the cranberry marsh is unequal throughout the year. In winter a caretaker may remain at the marsh while the grower–owner

FIGURE 16.—Cranberry cleaning machine. (Photograph by Wisconsin Department of Agriculture.)

FIGURE 17.—Crates ready for the cranberry harvest at the Biron Marsh. This marsh is the isolated one shown just northeast of Wisconsin Rapids on Figure 3. The factory water tank and smokestack are located at a manufactural site upon the Wisconsin River. (Photograph by Wisconsin Department of Agriculture.)

journeys to Florida, or spends the season in his city house. In spring a few workers are needed for dusting, weed-control, and ditch-cleaning operations. In the late summer harvest season the demand for workers is great and employment is at a peak for a three- to four-week period. The berries are harvested by means of the "Wisconsin scoop," which is swung across the top surface of semi-inundated vines (Figure 15). Berries, partly floating in the water, are scooped up, and the mass of harvested berries and vine pieces are taken to cleaning and grading machines (Figure 16). Harvesting in water is less harmful to the vines than "dry harvesting," and also results in less vine damage. The eventual marketing of the Wisconsin crop (Figure 17) is handled through the Wisconsin Cranberry Sales Company, an organization of most, though not all of the growers, and sales are made through the American Cranberry Exchange at New York and Chicago.

Workers for the harvest season have been obtained from several sources. Recent years have seen numerous local harvesters from near-by general farms or cities, or in northwestern Wisconsin harvesters who follow a life between some agricultural and some forest occupations. Indian workers were at one time of considerable numerical importance among central Wisconsin cranberry harvesters and still work in the bogs, since the sand-swamp bed of former Glacial Lake Wisconsin is one of the remaining areas within Wisconsin of fairly numerous Indian inhabitants.

REGIONAL PROBLEMS

The Wisconsin cranberry bogs are not located in similar environments, though all are in the same state. They are not in a compact area, as are most of the Massachusetts bogs. As a result there is a great deal of regional diversity among Wisconsin cranberry districts, chief of which is in the geographical pattern of layout and in water source. In the Cranmoor region the producing bogs are located on one extensive marshland, an area containing but little "highland." In the Mather-Warrens district the cranberry marshes are scattered over a wider area and are usually located on small stream flood plains in a mixed marsh and highland district. In northwestern Wisconsin the bogs are even more scattered in place location, and commonly possess the riverine pattern, though a few are laid out along the shores of lakes (Figures 5, 7, 8, and 10).

Flooding water varies in its origin, since it may be surface marsh water, ground water, or obtained from flowing streams or a natural lake. Flooding water also varies from medium hard to soft in type. Professor Neil Stevens of the University of Illinois, who is the

present cranberry field investigator of the Wisconsin Department of Agriculture, has noted possible relationships between alkalinity of flooding waters and the lack of productiveness of certain bogs. These, as well as many botanical and entomological problems, lie beyond the province of the geographer, yet serve to delimit and define regional distinctions; for example, Professor Stevens has suggested that there may be more than a casual relationship between alkali flooding waters on the cranberry marshes of the Berlin region and the decline of the marshes in the area which was the cradle of the Wisconsin cranberry industry; as pointed out, only one commercial marsh remains. Cranberry specialists and the Wisconsin Land Economic Inventory have inaugurated studies of the source and hardness of flooding waters. In effect this means practically the study of every cranberry marsh, since patterns differ from place to place, though they may be grouped geographically into the four major regional associations in Wisconsin.

PRESENT SCENE

The Wisconsin cranberry industry has been developed over a period of nearly one hundred years largely by native American growers. Of the present Wisconsin producers over one-half are descended from Wisconsin pioneers of early American stock, one-eighth are companies or corporations composed mainly of individuals of the same background, and one-fourth are Americans of German descent. A great many of the present marsh operators, particularly in the central Wisconsin area, are sons or grandsons of the earliest cranberry men, and have grown up with the industry. The remaining Wisconsin cranberry marshes are operated by individuals with Scandinavian or Polish names, descended from more recent immigrants. Workers, like owners, are predominantly of native stock, and residents of the various communities in which the industry is located.

Buildings of the cranberry farm are large and substantial (Figure 18). A large home for the owner is usual. These buildings in the sand-swamp area of the bed of Glacial Lake Wisconsin contrast most strikingly with the poor houses and barns of adjacent sand-land farmers. Warehouses and cleaning sheds, or a single building serving both functions, are usual. A caretaker's home

FIGURE 18.—A cranberry grower's farmstead in Washburn County, northwestern Wisconsin. (Photograph by Wisconsin Department of Agriculture.)

may likewise be present, and on some of the marshes is the only permanently occupied dwelling.

Cranberry acreages have been extended in Wisconsin, despite an apparent climatic handicap, for man has devised methods of meeting the situation. Dozens of problems constantly face the grower; there are price factors, insect pests, plant disease, unseasonable weather, water failure, flooding problems (such as introduction of weed seeds in the flood waters) and a host of others. Yet individually and collectively these men have been able to turn an original wild marshland berry crop into a profitable and highly developed agricultural crop, and to develop seemingly worthless wet land into high valuation cranberry bogs and flowage areas.

SOILS AND FARM ECONOMY ABOUT MOUNT WARNER, MASSACHUSETTS

Louis Kostanick and Merle Prunty, Jr.

IN considering the edaphic relationships of an area, the geographer in most cases omits the economic implications of soil variations, or treats them in the reflected light of land utilization. That farm economies vary among soil types is recognized, but adjustments of economy to minor soil variations usually receive scant attention. Land utilization research in an area often indicates change in agricultural adjustment to soil conditions, but infrequently does such research indicate the degree and scope of change in an exact manner.

In attempting to evaluate the significance of varied soil types in farm economy the writers surveyed intensively a small area, containing critical soils boundaries, in the Connecticut River Valley of Massachusetts. A field reconnaissance determined the selection of a problem area, one and one-half miles square, located in Hampshire County, west of the town of Amherst, and east-southeast of Mount Warner (Figure 1). Careful reconnaissance indicated the physical nature of the area selected, and something of its agricultural use (Figure 2).

After detailed mapping, the problem assumed a three-fold aspect: (1) what correspondence exists between changes in soils and land utilization; (2) how intimately adjusted to soils are farm economies of the area; and (3) what cultural responses may be attributed to variations in soils? Analysis of farm operation costs, investments, and profits, accompanied by detailed mapping of significant local features, completed field work.

Physical Setting

Physiographically the area under consideration is a small segment of the lowland belt of the Connecticut River Valley. Except for Mount Warner, all surface features within the reconnaissance area are of Pleistocene, or later, origin. Mount Warner (Figure 2, C-8) rises roughly four hundred feet above the Connecticut River, which flows about one-half mile west of the mountain. This erosional remnant is a schistic structure. Associated with Mount Warner is the most significant physiographic feature, from an economic viewpoint, in the area—the Mount Warner delta (Figure 2, D-E, 4–8).

It is generally believed that whatever the mode of ice retreat may have been, the Pleistocene glacial deposits of much of the Connecticut Valley were associated with a body of water which was pro-glacial. Recent detailed studies now indicate that the general direction of deglaciation appears to have been from southeast to north-northwest, that a single large body of open water probably existed in the Connecticut Valley, and that it grew northward as the ice receded. (Source: R. H. Jahns and M. E. Willard: *Late Pleistocene and Recent Deposits in the Connecticut Valley, Massachusetts;* American Journal of Science, Vol. 240, March and April, 1942.)

From an elevation of 280 feet, south of Mount Warner, the delta structure extends east-southeastward, terminating at about 165 feet elevation. Obviously the source of the material deposited in the delta was northwest of Mount

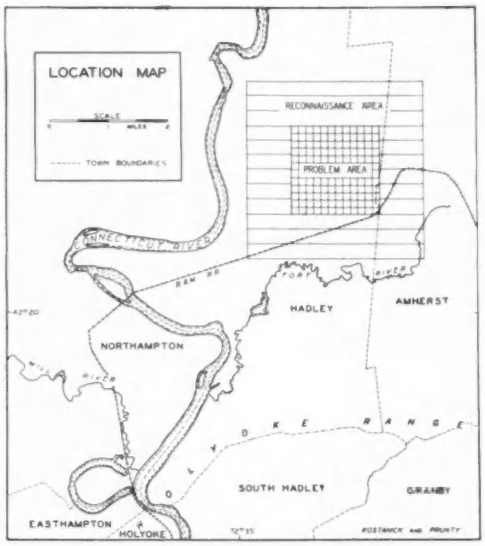


FIGURE 1.—Reconnaissance and problem areas in the Connecticut Valley, Massachusetts. The area selected for investigation is a small portion of the Connecticut Valley lowland, located between the Connecticut River and Amherst Town, north of the Holyoke range, northeast of Northampton and west of Amherst.

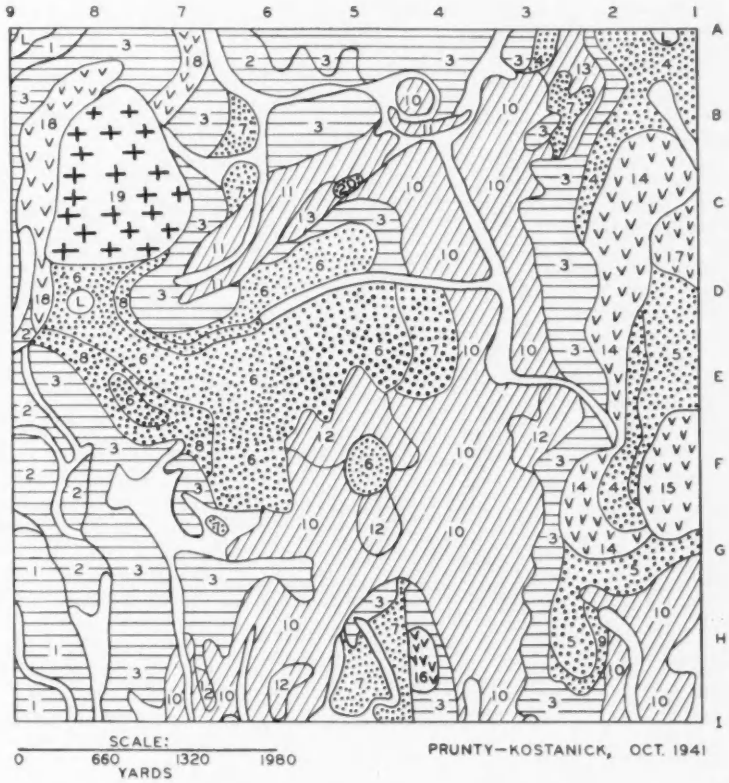
Warner, and this source must have been ice itself. The general trend of the delta structure from northwest to southeast is in correspondence with the Jahns-Willard suggestion as to the trend of deglaciation. It is possible that Mount Warner acted as a wedge on the underside of the ice sheet which weakened the sheet, cracked it, and caused the local drainage of the glacier to pour around the mountain's southwestern side. Terraces of glacial origin also exist along the eastern portion of the reconnaissance area (Figure 2).

Evidence of a glacial lake is widespread in the lake plain section of the reconnaissance area. Varved clays are found close to the surface on the lake plain; at D-5 (Figure 2) varved clay exposures may be found in the bed of a small stream flowing off to the delta structure. Clays of the lake plain contain a high percentage of silt, and in some localities adjacent to the delta, small, pea-sized pebbles are found in a few of the upper varves (Figure 2, F-5.5). Recent stream action of the Connecticut River and its tributaries has reworked and redeposited materials of glacial origin in the western and northern portions of the reconnaissance area, in addition to depositing fluviatile materials.

Soils in the problem area necessarily reflect the characteristics of the underlying materials. Thus the Chicopee-Melrose-Manchester series, which are developed upon the delta structure and its slopes, have light colored surfaces, with gravelly and sandy substrata, and range from fine sandy loams to a few small areas of gravelly sandy loams, while the Suffield-Scarboro series, which are found on the lake-plains and are developed from clay materials, are heavy textured, in general, with heavy silty clay or clay subsoils and substrata (Figures 2 and 3). (Analytic material on soil characteristics largely based upon W. J. Latimer and L. R. Smith: *Soil Survey of Hampden and Hampshire Counties, Massachusetts;* United States Department of Agriculture, Washington, D. C., 1932.)

Chicopee fine sandy loam, developed on glacial terraces and especially on deltaic structures, is the most important soil on a value-per-acre basis. This soil is not innately fertile, but is more productive than other sandy terrace soils within the problem area. Moisture holding capacity is fairly good. Because of the deltaic nature of the Chicopee in the problem area, permeability is high, and tobacco roots are not affected by an excessive subsoil water content. Normally, special crops are not grown without heavy fertilization (Figure 3, G 9-11).

Manchester gravelly fine sandy loam is similar in its general characteristics to Chicopee, but, in the problem area, is not so important a soil due to its ten-



SOILS OF THE ALLUVIAL TERRACES:
1—Hadley very fine sandy loam
2—Hadley silt loam—overflow phase
3—Agawam fine sandy loam

LAKE-PLAIN SOILS:
10—Suffield silt loam
11—Suffield, heavy phase
12—Suffield fine sandy loam
13—Scarboro loam

SOILS OF THE GLACIAL—DELTAIC TERRACES:
4—Merrimac coarse sandy loam
5—Merrimac sandy loam
6—Chicopee fine sandy loam
7—Melrose fine sandy loam
8—Manchester gravelly fine sandy loam
9—Hinckley gravelly sandy loam
20—Windsor loamy fine sand

HILL SOILS:
14—Cheshire sandy loam
15—Cheshire sandy loam, gravelly phase
16—Cheshire fine sandy loam
17—Wethersford loam
18—Gloucester stony fine sandy loam

OTHER SOILS:
19—Rough stony land (Mt. Warner)
—Alluvium, muck, meadow
L—Water body

FIGURE 2.—Physical features of the reconnaissance area as indicated by soils. The relations of the glacial delta to Mount Warner and the lake plain are revealed by the distribution of soils developed upon the several physiographic features of the reconnaissance area.

dency to leach. This condition is due principally to the porous, gravelly character of the subsoil (Figure 3, J-3). Melrose fine sandy loam normally occupies fairly level terraces; in the problem area Melrose is located on the Mount Warner delta front. Areally and in characteristics it is closely

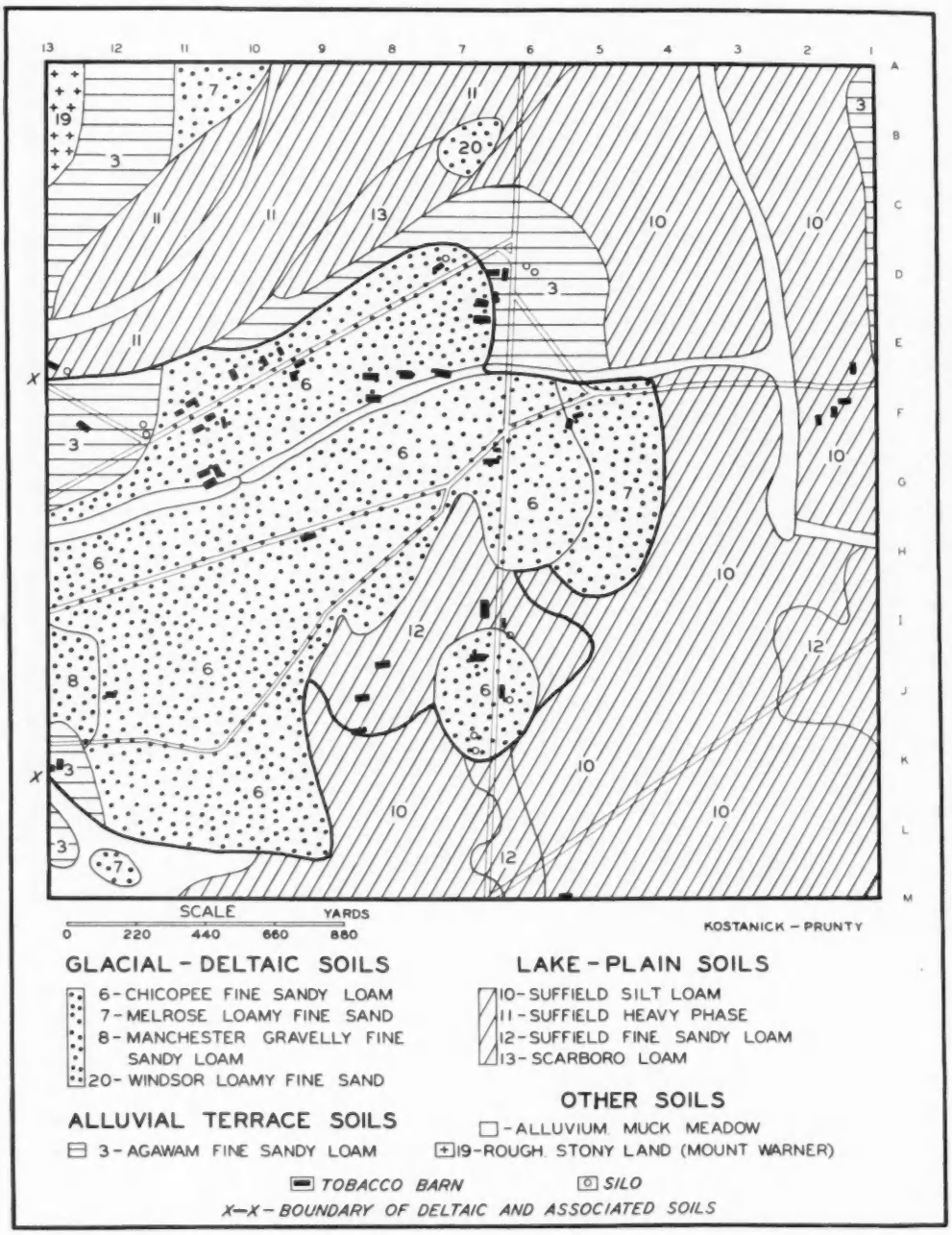

SCALE
YARDS
0 220 440 660 880
KOSTANICK – PRUNTY
GLACIAL – DELTAIC SOILS
6 – CHICOPEE FINE SANDY LOAM
7 – MELROSE LOAMY FINE SAND
8 – MANCHESTER GRAVELLY FINE SANDY LOAM
20 – WINDSOR LOAMY FINE SAND
LAKE – PLAIN SOILS
10 – SUFFIELD SILT LOAM
11 – SUFFIELD HEAVY PHASE
12 – SUFFIELD FINE SANDY LOAM
13 – SCARBORO LOAM
ALLUVIAL TERRACE SOILS
3 – AGAWAM FINE SANDY LOAM
OTHER SOILS
– ALLUVIUM, MUCK, MEADOW
19 – ROUGH, STONY LAND (MOUNT WARNER)
TOBACCO BARN
SILO
X–X – BOUNDARY OF DELTAIC AND ASSOCIATED SOILS

FIGURE 3.—Distribution of soils in the problem area. The marked concentration of tobacco barns on the glacial-deltaic soils reflects the dominant crop association of the area.

associated with the Chicopee, but is distinguished from that soil by its slightly darker surface color and mottled condition of the subsoil, which is caused by moisture held by the tight clay strata that underlie the soil at a depth ranging from three to five feet. It is well suited to tobacco and onion culture

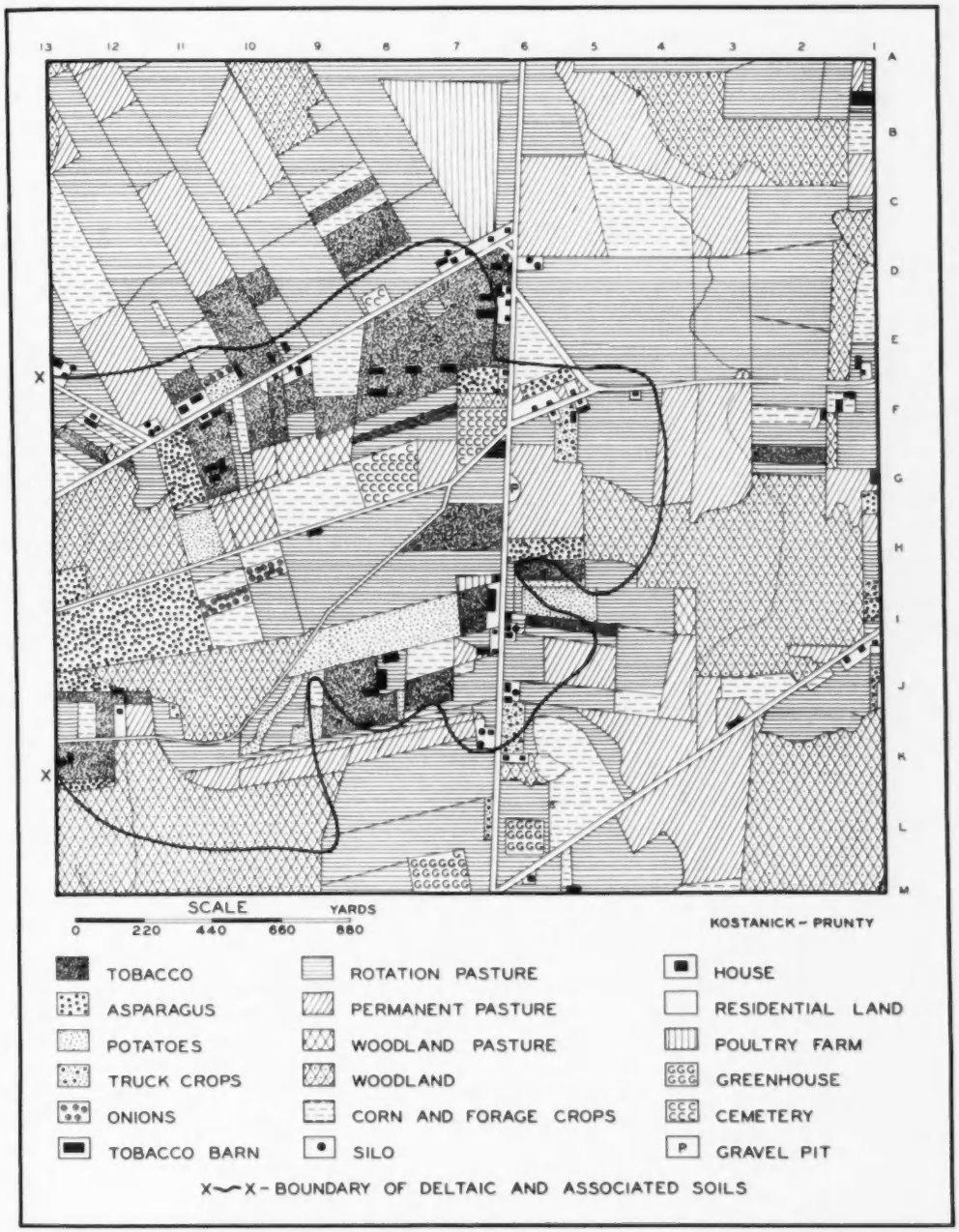


FIGURE 4.—Land utilization in the problem area. Intensive utilization of the deltaic soils as shown by the tobacco-asparagus-potato crop association contrasts with the hay-pasture pattern in field size and shape, in addition to contrasts in economies and cultures.

(Figure 3, G 4–5). Windsor loamy fine sand has a tendency to drift, and while it is cultivated in the Connecticut Valley in many places, it is of almost no significance in the problem area (Figure 3, B-7).

Suffield silt loam is derived from beds of clay, has little relief, and is subject to retarded drainage due to clay subsoil and varved substrata. Normally hay and pasture form the most extensive use for this soil (Figure 3, 4, A-M). Suffield, heavy phase, actually is a silty clay loam, and is used solely for pasture and hay (Figure 3, B-9). Suffield fine sandy loam is characterized by sandy material overlying a clay bed. The brown surface soil with its yellowish brown subsoil is underlain at a depth of about two feet by a green-tinged, fairly heavy clay substratum. Because the clay substratum holds moisture, crops on this soil rarely suffer from drought. Conversely excessively wet seasons may cause crop failure. The Suffield fine sandy loam's association with the delta front in the problem area, and its consequent sandy character, immediately is evident. Wash from the delta structure, deposited upon clay materials, has been equally important with the clay in formation of a soil which, in the problem area, reflects characteristics of both materials (Figure 3, 1–7). The Scarboro loam is unimportant. It occupies a flat, poorly drained depression on a terrace soil, and indicates immature development (Figure 3, C-8).

The Agawam fine sandy loam is a high terrace soil, and is an old alluvial soil with a poorly defined profile. Surface relief is fairly level, drainage is well established, and the subsoil lacks sufficient porosity for excessive sub-surface drainage. Tobacco does well on this soil, but corn for silage, onions, and grain corn are not so productive as on other alluvial soils, notably the Hadley very fine sandy loam (Figure 3, B-12, F-12, D-6). Other soils of the problem area (alluvium, muck, meadow, rough stony land) need no amplification.

FIGURE 5.—Dairy-pasture lake-level landscape in the foreground, tobacco-truck delta slopes in the middle distance, and the forested stony crest of Mount Warner on the horizon.

Climatically the area is humid, marked by long, cold winters and comparatively short, but warm summers (Table I). Conditions are well suited to the growth of general farm crops, market gardening, and poultry, but dairying, orcharding, and live-stock raising are somewhat hampered by the short growing season. Precipitation is well distributed throughout the year, and normally sufficient moisture is available for crops through-

TABLE I

AVERAGE MONTHLY PRECIPITATION, TEMPERATURE AND SNOWFALL, AMHERST, MASSACHUSETTS

	J	F	M	A	M	J	J	A	S	O	N	D
Temperature Fahrenheit	23.8	22.3	34.5	45.7	57.0	64.6	71.0	68.4	61.4	51.5	38.3	27.8
Precipitation Inches	3.38	3.27	3.60	3.18	3.80	3.61	4.40	4.36	3.66	3.71	3.62	3.58
Snowfall Inches	12.0	15.0	8.6	2.0	.....	.....	.....	.....	.....	.....	2.1	9.6

Elevation—222 feet
Average Temperature—47.2 degrees
Average Precipitation—44.17 inches
Average Snowfall—49.3 inches

out the growing season. Variations from the normal (average) precipitation are most marked during the summer season.

The active growing season of about five and one-half months is ample for maturing of most crops in the area; frequently corn suffers from frost damage in late spring and early fall. Winters are such that livestock must be well housed. Even on dairy farms, where work is fairly evenly distributed throughout the year, the summer season includes a concentration of work-hours. This concentration is much more marked on certain other types of farms. Although climatic conditions affect the area uniformly, precipitation indirectly contributes to the characteristics of the lake plain in conjunction with the physically contributed clay strata, thus creating the high water-table which limits the land utilization possibilities of that section.

CONTRASTS IN LAND UTILIZATION AND ECONOMY

The pattern of land utilization within the problem area indicates close adjustment to soil conditions. Particularly noticeable is the location of tobacco, onion, and potato fields in relation to the glacial-deltaic soils, especially the Chicopee; in a similar manner the Suffield series of the lake plain soils is reflected in pasture-hay utilization of most of the eastern portion of the problem area (Figures 3 and 4). Tobacco fields are found along the eastern margin of the problem area on small Agawam fine sandy loam terraces. The Agawam is a tobacco soil of major importance in the Connecticut Valley,

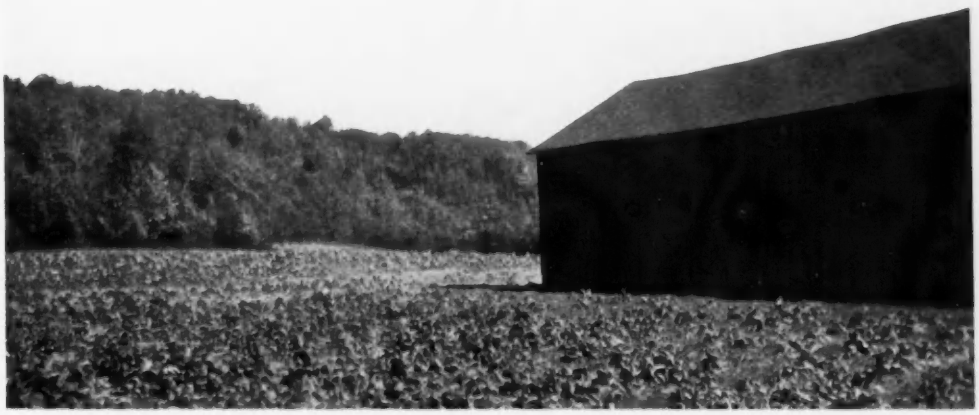


FIGURE 6.—Tobacco-field, tobacco-barn detail on the upper edge of the delta against the forested buttresses of Mount Warner.

but is relatively insignificant in the problem area. Since tobacco does not prosper in any soil where a high water level threatens its roots, and, since grasses and legumes can be materially benefited by a high water-table (due, in this instance, to clay substrata), the correspondence existing between changes from delta to lake plain in soils and in land utilization is nearly exact. In certain fields farmers were able to point out definitely where conditions unfavorable to tobacco production became dominant, and beyond these points tobacco is not found except for small marginal areas caused by current high prices (Figure 4, C-9).

References to changes in soils henceforth refer to the outer margins of those soils which are associated with the delta structure (Figures 3 and 4, X-X). Within the section X-X small areas of Agawam fine sandy loam have been included (Figure 3, F-12, K-13) as associated deltaic soils, since, like the Suffield fine sandy loam, these areas are characterized by wash from the delta structure up to a depth of two and one-half feet. Consequently, the Agawam in these areas shows marked similarity to the true delta soils. At D-6 (Figure 3) a considerable area of Agawam fine sandy loam has been excluded, since overdeposits from the delta have been insignificant and the characteristics of the area more closely resemble the adjacent lake plain soils than the glacial-deltaic group.

Within the area X-X (Figures 3 and 4) it has been impossible to determine the significance of soil changes as reflected in economic responses, since no constants in fertilizer, labor, and power costs could be established to serve as a base upon which to compare per-acre profits. Conversely, on the lake plain no significant changes could be observed in correspondence with soil boundaries, and since no contrast in either farm operating costs or per-acre return could be

FIGURE 7.—Long, narrow barns, easily opened for ventilation and desiccation of the stored tobacco demand an investment of about $250 per acre produced.

FIGURE 8.—Open woodlands, permanent pasture, and rotation meadow on the water-retentive Suffield soils furnish ample grazing during the open season for an adequate supply of heifer replacements for sustained dairy herds.

obtained, no significance is attached to soil changes in that area.

Because of the intimate relationship of tobacco, onion, asparagus, and potato production to the glacial-deltaic soils, especially as indicated by the location of tobacco barns, the glacial-deltaic soils area will be referred to as the "tobaccoland." Although tobacco averages but 13.7 per cent of the average tobaccoland farm acreage, this crop is characteristic of the area in cultivation and production methods, is the basic farm product of the section, and is representative of the investment-profit relationship of the glacial-deltaic area. Onion, asparagus, and potato culture is directly attributable to the economics of tobacco growing. Heavy fertilization necessary for tobacco growing, innate productivity of the tobacco soils, the necessity for rotation of crops upon tobaccolands, government acreage restrictions and the pattern of labor activities delimited for the farmer by an economy based upon tobacco—these features have contributed to the production of onions, asparagus, and potatoes as a corollary to tobacco culture. Because these crops follow tobacco in the field, and are not fertilized, but depend upon fertilizer remaining from the previous season, the investment necessary for their production is not so high as that necessary for tobacco. The relation, however, between average investments and profits in onion, asparagus, and potato production, is practically the same as that for tobacco, with two additions: (1) a greater range in variation of prices from the mean price may be expected, and (2) the profit-balance received from these commodities approximates and remains nearly constant with the profit-balance obtained from tobacco.

Similarly, the term "dairyland," will be used in reference to the lake plain area; this commodity (dairy products) so dominates the productions of the dairyland that no weighting to determine the accuracy of an average crop, as in the case of tobacco, has been necessary.

The tobaccoland includes Suffield fine sandy loam at I, 7–8 (Figure 3), due to conditions previously mentioned, the Agawam areas adjacent to the delta at K-13 and F-12 (Figure 3), and the glacial-deltaic soils between C-L (Figure 3), though much of the southwestern por-

tion of this area is in woodland. Dairyland includes the balance of the problem area.

Chicken farms represent a land utilization type which is not directly dependent upon soil and other physical conditions for determination of its essential characteristics; rather, chicken farms are similar to manufacturing plants in their land relationship, for chicken production remains essentially the transformation of raw materials (foodstuffs) into finished products (eggs and poultry) with the land occupance entering the production cycle only because of site factor. Hence chicken farms are disregarded, since their production-investment-profit relations cannot be considered indicative of soil differences.

Two large greenhouses within the problem area at M-7, and L-6 (Figure 4) owe their location to peculiar soil conditions. The clay substrata of the Suffield silt loam have been effective in producing soil conditions considered nearly ideal for rose culture; the location of the greenhouses is intermediate between the marked sandy-gravelly portions of the Suffield adjacent to the delta structure, and the poorly defined and developed Suffield with clay substrata close to the surface, which is directly south of the problem area. The high silt factor in the Suffield silt loam, plus the moisture control afforded by its clay subsoil, offers almost ideal conditions for rose culture.

Accompanying the change in intensity and character of land utilization, and adjusted to soil conditions, are changes in mechanization and disposition of farm labor. Density and type of population also are associated with changes in soil.

Within the problem area are one retail dairy, three dairies selling to milk distributors, one tobacco-dairy farm in which tobacco dominates, one dairy-tobacco farm, in which dairying dominates, nine tobacco farms, two chicken farms, three greenhouses, two of which are quite large, and one farm specializing in cattle for beef.

Farms in the problem area vary in size from 50 to 375 acres. The average size tobaccoland farm is 68 acres, while the average size dairy farm is 239 acres. Land values vary greatly, even within a farm, and estimates are hard to obtain. It is a general practice within the Connecticut Valley to value land on the basis of what it can produce; two fields within a short distance of each other may vary as much as $150 per acre in value. Hence, "good tobaccoland" (Agawam fine sandy loam, Chicopee fine sandy loam, or glacial-deltaic soil) varies in price estimates from $150 to $250 per acre. The lake plain soils (Suffield series) vary in estimated value from $75 to $110 per acre, with an average of estimates at $85. In correspondence with land values, land rents vary. Glacial-deltaic soils command rents of $20 to $30 per acre per annum, depending upon a variety of factors, while lake plain soils normally rent for $6.00 to $8.00 per acre per annum.

Cultivating machinery, on tobaccoland farms, represents an average investment of $550, and is designed for use with horses, while on the dairyland farms, investments in cultivating machinery average $2,200 and exceed, in one instance, $3,600. Fixed farm machinery (milking equipment, milk coolers and bottlers, hammermills, silage fillers and cutters, electric motors and other similar equipment) represents an average investment of $2,300, but this item was non-existent in sums of more than $350 on all but one tobacco-specialty farm. (Investment averages herein involved are based on replace-

ment cost, and depreciation has been disregarded.)

Excluding homes, investments in farm buildings varied from $2,000 to $8,000 with greater investments in barns and silos on dairy farms than in tobacco and livestock barns on tobaccoland farms. Average barn value, for drying and sheltering tobacco, is $250 per acre of tobacco, though naturally this figure varies in accord with lumber prices at time of construction. Thus the tobacco farmer, raising an average of nine acres of tobacco, has a replacement investment of $2,250 in tobacco barns alone, plus an average investment of $1,500 in livestock barns. One dairy farm owner, conversely, has over $8,000 invested in barns, silos, and barn equipment, while the average value of dairy farm buildings is $5,800.

Power costs, for cultivation, average $10 to $12 per acre for farms on glacial-deltaic soils. No farm specializing in tobacco-potato-onion production has tractor equipment. Three horses per average farm of 68 acres is the standard. Power costs include costs of year-round maintenance, except pasture, but do not include initial investment cost. Dairyland farms average one tractor per farm, and appropriate equipment. No power cost estimate for this group of farms exceeds four dollars per acre. Certain portions of each dairy farm receive careful cultivation, notably corn-fields, and consume a disproportionate share of the annual power output. Over 60 per cent of the farm power used on dairylands, however, is expended upon hay-pasture fields.

Fertilizer costs indicate even more divergence. Per acre, the average expenditure for commercial fertilizer on the tobaccolands was $85, but it should be remembered that commercial fertilizer is applied only to specialized crops (tobacco, potatoes, onions, asparagus, the last three usually depending upon fertilizer applied to tobacco), that these crops total less than 170 acres of the problem area, and that this acreage is divided among ten farms. On dairy farms the expenditures for commercial fertilizers are negligible, but cow manure (value not estimated) is conserved and used. (Figures herein presented are averages of three-year period, 1939–1941, where available.)

Computation of labor costs involved in dairy farm operation is relatively simple, since permanent, year-round

FIGURE 9.—The long rigorous season of stall feeding requires an abundant supply of ensilage and forage to supplement the pasture—rotation meadow and permanent grass—which is ample for the period of open grazing. The barn and silos provide storage capacity for hay and ensilage; the productive meadows, heavily manured, and the well-watered lowland pastures, the grass.

FIGURE 10.—Tobacco harvest is a time of busy and strenuous devotion to the work in hand. The tobacco must be taken to the barns expeditiously, carefully, and promptly. Labor requirements for this season are heavy and urgent. A field rack for taking cut tobacco to the drying barn is part of every tobacco farmer's equipment. (Courtesy of Dr. W. Elmer Ekblaw.)

labor without great seasonal variation is necessary. On a per acre basis, the dairyland area averaged a labor cost of $19 per acre, excluding owner-labor. Forty-two per cent of the labor employed upon dairylands in the area was supplied by the owner's family. Labor in tobacco and specialty crops production is a highly seasonal factor; nearly two-thirds of the necessary labor output was expended in the harvest season. Experienced tobacco hands now command as high as $5.00 daily. (Some operators expect to be forced to pay even higher wages next season.) Per acre, the average of labor expenditures on tobaccolands is $105, but this figure includes estimates of the value of family labor in addition to prices for seasonal labor. (Few Polish farmers keep records, and therefore value of family labor was based upon daily wage rates paid seasonal labor.) Because of the high figure, and obvious inaccuracy of data, it is believed that the average cost presented is $10 to $15 per acre higher than the actual average. Seventy-five per cent of the labor required on the tobaccoland farms is supplied by the farm families. It is not unusual to see an entire family working together in one field.

Disparity in farm sizes and numbers in farm families between the tobacco and dairy sections of the problem area may be partially explained on a profit basis; indeed, since there is contrast in size, families, type of product, methods employed and mechanization involved, a comparison of profits derived is indicative of soil significance in utilization and farming techniques. Thus a measure of the relative intensity of utilization may be obtained with reasonable accuracy.

At current retail milk prices in the area, a herd averaging 7,300 pounds of milk yearly per cow, will produce an income (gross) of $627 per cow. Dairies selling to wholesale milk purchasers will receive an average of 40 per cent of the retail price, thus herds averaging 7,300

pounds of milk will show a gross return per cow of $251, or an average per acre basis (average dairy acreage, 239 acres, average herd, 50 producing cows) a gross return of $52. When depreciation on buildings, stationary and cultivating equipment, labor charges, feed costs, animal maintenance and replacement costs are deducted, a net profit of $12 per acre is obtained. This figure is subject to insurance, tax and home maintenance expenditures, which have not been deducted, and does not include an owner wage.

Tobaccoland requires labor averaging in value, per acre, $105, fertilizer averaging $79, power, equipment, and depreciation valued at $15 per acre, and barn investments of $12.50 per acre per annum (at twenty year maturity). Average profits per acre from tobaccoland are $50. This figure is subject to insurance, tax, home maintenance, and owner-wage deductions. An average per-acre profit from tobaccolands of $50 is an apparent return, however, for it must be remembered that an average of 75 per cent of the labor required upon tobacco in the problem area is supplied by family labor. Thus the farmer receives, on an average, $79 additional ($129 total) return from tobacco per acre. (Figures are averages of three years 1939–41, where available.)

Disparity in average farm and family size cannot be explained entirely upon the relative profits derived from the two economies. Cultural factors are involved. A lower living standard obviously prevails on the tobaccoland. That the variation between the living standards of the Poles on the tobaccoland and the Yankees on the dairyland is not greater may be attributed to the differences between the tobaccoland's high per-acre return and the dairyland's low per-acre return.

CULTURAL RESPONSES

Variation in land utilization and economy between the tobaccoland and dairyland is correspondingly reflected in types of people living in the two sections. Polish people own and farm the tobaccoland, while the dairyland is owned and operated by descendants of old Yankee stock.

Fifty years ago Yankees lived on both

FIGURE 11.—Polish family husking corn for grain from the shock on a former tobacco field on the Mount Warner delta. The fodder is taken to the barn for late fall forage. Work in the fields in fair weather is healthful and invigorating.

tobaccoland and dairyland. Even at that time land use contrasted, for profitable tobacco culture had begun at an early date. In the last forty years, however, Polish immigrants have superseded the Yankee farmers on the delta and now own most of the land and produce most of the tobacco grown in the area. This is due primarily to the willingness of the Poles to work harder and longer than the Yankee farmers who are reluctant to do the back-breaking work necessary for production of high grade tobacco and onions.

Polish families began immigration to the area around the turn of the century. Wages were high and prospects good. The Poles were hard workers and were much in demand as laborers. Later immigrants came to join their friends and relatives. Through thrift and frugality they saved money and soon bought farms. When they did not have the cash necessary, loans were easily obtained, for the Poles created a reputation for honesty and thrift. By 1913, Poles owned most of the tobaccoland while Yankee farmers continued to own the dairyland.

The Poles form a distinct ethnic group on the tobaccoland. All speak Polish, most of them, in fact, better than they speak English. Many came from the same region in Europe—Galicia and other parts of former Polish Austria-Hungary. Families are large (one farmer has eleven children) for children mean much-needed help on the farm. Children all work on the farm, receiving in return not wages but their necessary food and clothing. In the winter the older children work in the factories and mills nearby, but in summer return to work on the farms. Married children work in nearby mills or as laborers on farms. Few of the children finish high school and none go to college.

Most of the Polish customs are retained even by the American-born Poles. The church serves as a gathering place and social center, and church holidays are observed in much the same way as in Poland. The Easter "Paska," or holy bread, served to all visitors, is still put on the dining table with colored Easter eggs. Baskets of eggs, cakes, cookies, and breads are carried into the church for their blessing by the local priest. All of the Poles are Catholic and have their sermons and services sung in Polish by the local priest.

Polish people exhibit social attitudes quite different from those of the Yankees. They are friendlier, more hospitable, and more willing to talk with strangers than their Yankee neighbors. They retain an obvious love for the land which the Yankee farmer does not show. Long centuries of back-breaking work in Europe make the arduous tasks of weeding by hand, hoeing, and planting seem less menial than they appear to the native-born farmer.

Yankee farmers show the traits of the traditional New Englander: conservatism, thrift, hard work and cleanliness. Almost all Yankees of the problem area are of the third generation, born in the immediate vicinity, and quite proud of their family histories. Families are small—two or three children comprise, with their parents, the average family unit. Most of the farms were inherited. All are well-kept. Capital invested in the farms is large, since the savings of three generations usually have gone into purchasing and equipping land.

Yankee families are better educated than the Polish families. Some of the children of Yankee families are students in nearby Massachusetts State College. All of them attend the churches of

their forefathers—Unitarian, Methodist and Episcopalian.

Thus cultural elements indicate marked differences attributable to adaptations which have been fostered by contrasting edaphic conditions. These cultural differences are attributable to differences in the two types of land utilization, which, in turn, are based primarily upon soil differences. The exacting labor requirements of the tobaccoland have been the cardinal factor in the settlement of that area by the Poles. Thus, although soils have not directly produced these cultural variations, the distribution of Yankees and Poles, and hence of cultural types, is a direct response to edaphic conditions.

SUMMARY

Within the problem area, correspondence of different soil to changes in land utilization is nearly exact. In some instances where a soil boundary bisects a field, land utilization corresponds to that boundary with the smallest of discrepancies. In other locations, where field boundaries are not in correspondence with soil boundaries, the outer limit of a field through which a soil boundary passes marks the maximum deviation from the soil boundary. It should be mentioned, however, that such correspondence is observed only on land being actively cultivated, and that a considerable proportion of the problem area is in low-grade forest.

A marked change in farm economies, based on different soils, coincides with land utilization variations. The resultant contrasting dairyland and tobaccoland economies indicate a per-acre return roughly four times greater for the latter than for the former; a converse ratio exists in average farm sizes between the two sections. The intimate economic adjustments necessary, in each section, to specific soil conditions characterize, limit, and intensify the attributes of the two areas. The degree and scope of change in land utilization in the problem area is capable of mensuration by consideration of resultant farm economies.

Cultural responses to different soils and resultant economies in the problem area contribute to contrasts between the tobaccoland and dairyland sections in size of family, nationality, religion, length of land tenure, social attitudes, labor conditions, educational achievements, and standards of living.

POPULATION TRENDS IN MINNESOTA—1940

Leonard S. Wilson

ANY census year offers the citizens of the United States opportunity to take inventory of their country. The 1940 report of the Bureau of the Census is especially interesting because of the economic conditions which have characterized the past decade. During most of this period the primary production of the country has been curtailed. The effect of this circumstance upon the distribution of people and upon the establishment of new trends in population growth is of more than academic interest. Just as the history of settlement explains the present-day distribution of people, so future patterns of occupance may be broadly interpreted from present movements. Trends of little moment today will have a marked effect on the country of tomorrow. Some of these may be beneficial, while others, unless checked at the outset, will be detrimental to the public welfare.

These trends are observable in all parts of the country and will vary from section to section. However, the information available in the Census is uniform for the nation as a whole. An examination of the trends in Minnesota, while they are representative of conditions within that state alone, exemplifies the use of census material for a geographic study of the future population problems of the United States.

The agricultural population and its problems is of paramount interest to Minnesota. Any question affecting farmers has a corresponding impact upon all others. The past decade has witnessed the beginnings of certain drifts that are capable of changing the location of many rural families within the state. An examination of these incipient movements will clarify future land use problems.

History

The 1940 Census records the condition of Minnesota at the present time. As such it presents a static picture of the results of settlement since early time. Today the agricultural development has completed a major transition. Wheat was the chief crop prior to 1920, but during the past twenty years grain cultivation declined until only a small fraction of the former acreage remains. Between 1920 and 1940 the change from cash-grain planting to a more generalized corn-hog-cattle economy has been more pronounced in southern Minnesota. The result has been a more balanced and stable income for the farmers. However, it has also meant a transformation in crop production and settlement pattern. (Wilson, Leonard S., "Faribault, Minnesota," Proc. Minn. Acad. Sci., Vol. 7, 1939, pp. 77–82. St. Paul, Minn.)

Trends of the 1920–30 Decade.—Efforts of farm organizations as well as reduced profits from wheat, a characteristic of the years immediately following the war of 1914–18, turned the attention of the rural inhabitants to a more generalized type of agronomy. This is reflected by the declines in population throughout the minor civil divisions of the Red River Valley (Figure 1). Nearly every rural county in Minnesota decreased in population. Census returns show that the rural population declined 2.2 per cent during the decade. At the same time urban centers gained 19.6 per cent and the state as a whole in-

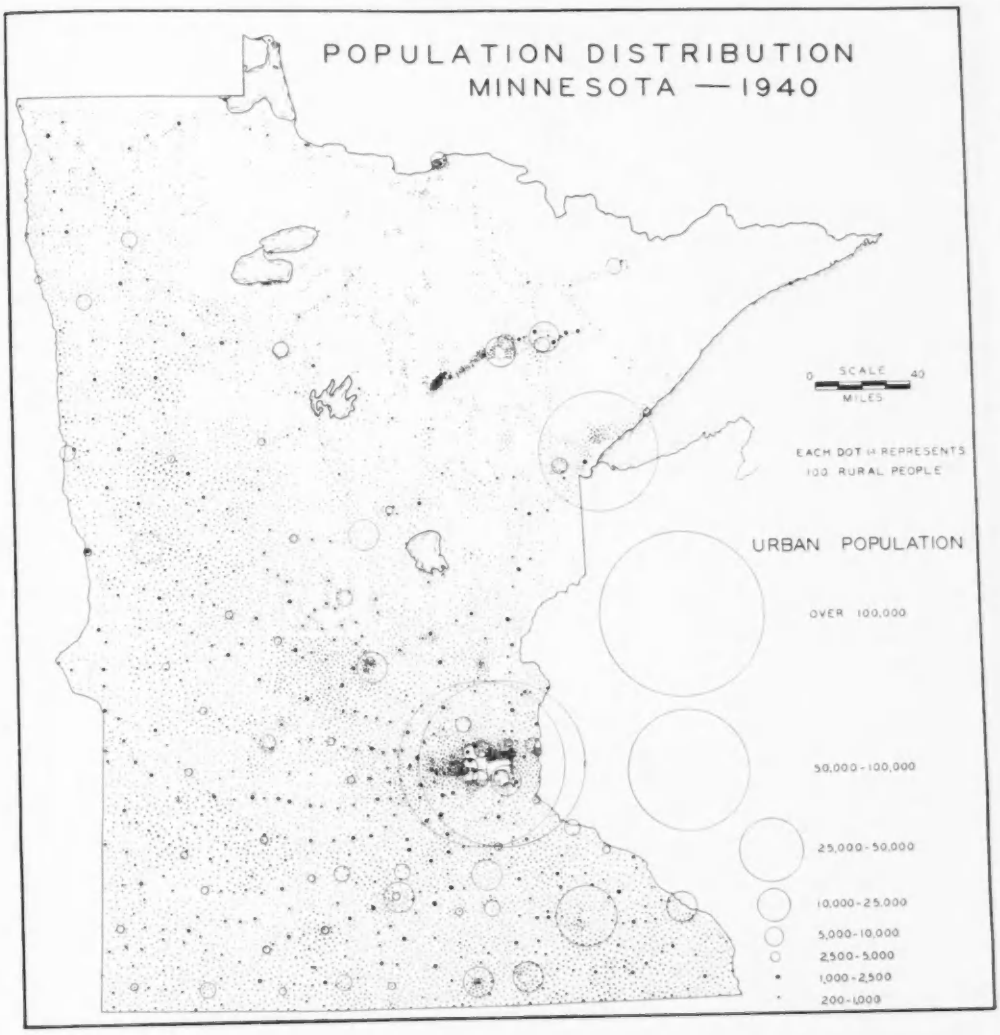


FIGURE 1.—The data from which this map was constructed was obtained from the Census of 1940, Population Statistics by Minor Civil Divisions. It will be noted that there is a fairly even spread of population over most parts of the state. In the northeast major clusters are located on the iron ranges and at Duluth, while in the northwest the population is mostly confined to the Red River Valley. For a comparison of former years see Wilson, Leonard S., "Some Notes on the Growth of Population in Minnesota," *The Geographical Review*, Vol. XXX, No. 4, Oct. 1940, pp. 660–664.

creased 7.4 per cent. The classification of growths and declines on both of the Population Trend Maps (Figures 2 and 3) was divided as follows: Actual Decline indicated a loss of population; Slow Growth was limited to those sections which gained less than 4 per cent; Normal Growth was confined to areas which gained between 4 and 12 per cent; Rapid Growth indicated an area which experienced an increase of 12 to 24 per cent, while Excessive Growth was limited to lands showing over 24 per cent gain in population for the decade.

Only one non-urban area showed excessive growth. The area of Mille Lacs County continued to expand despite unfavorable farming conditions and the exhaustion of commercial forests. This southern extension of the lake district

was the first part of Minnesota to respond to the growing interest of the public in outdoor recreation. Situated but a short distance from the major cities it afforded an early focal point for motor car travel and in this respect foreshadowed the development of the next few years.

Thus the major trends of the 1920–30 era included the decline of wheat farming and the substitution of more generalized land use in the agricultural areas of the state. No appreciable expansion took place; instead an actual decline was registered in all parts of the farming zone. Commercial lumbering had ended; a decline in the demand for iron ore, and new methods of mining, had led to population retreats in the iron range. This was the situation when the 1930–40 era began.

Trends of the 1930–1940 Decade.— The ten-year period just completed has been one of depressed agricultural prices, closed opportunities for urban employment, and has been marked by a return to a fundamental agricultural economy. The halting of depopulation has been aided by the federal program of price relief, and this policy combined with urban unemployment has made the land seem more attractive. Internal migration towards cities stopped and a gradual growth of population on nearly all lands began (Figure 2). The only exceptions to the expansion of settlement are found in Chisago, Lake, Lincoln, and Rock counties.

These instances demonstrate an increasing appreciation of the underlying qualities of Minnesota land. The poor sandy soils east of Minneapolis–St. Paul and the western drought areas have been the centers of abandonment. A closer adjustment to the potentialities of the fundament have been observed within recent years in most sections of Minnesota. Only a few districts are exceptions to this generalization, and these are the lands where some disharmony may be expected in the future. A failure to understand the limitations of a region may be reflected in a curve of population growth. Normal curves of population increase show rapid rise in immigration during pioneer times, and gradual flattening of the arc to a sustained density as settlement matures. In Minnesota a sufficient time has elapsed to enable settlement to be established on all types of land, and this had been done prior to the present decade. The knowledge of the state about its natural resources is sufficient to warrant the opinion that pioneer conditions should not be encountered today. However, growth in certain sections has approximated pioneer expansion, and if the rapid increase in population is followed by anticipated events, it will result in the closing of the pioneer cycle by an era of discouragement, hardship, and poverty. It is at the end of this cycle that outside aid becomes necessary.

Areas of rapid or excessive growth are confined to lands which have been scantily occupied in the past. The Mille Lacs district, which gained during the 1920–30 decade has continued to expand. This early center has extended until at present it touches most of the counties between Mille Lacs Lake and the north central border. An examination of the occupance indicates that settlers are engaged in small farming enterprises. The agricultural statistics of three of the most rapidly developing counties show that they are expanding crop production at a higher rate than the population increases would warrant (Table I).

Apparently the northern lands are assuming an important place in the economy of the state. While slight increases were registered in nearly all sections, the extension of farming in

TABLE I

AGRICULTURAL STATISTICS
(In Percentage Increases)

	Cass County	*Lake of the Woods County*	*Mahnomen County*
Number of farms	21.89	48.2	42.7
Cropland harvested	24.9	47.8	36.6
Proportion in farms (1940)	25.6	18.3	53.3
Corn (acres)	136.7	921.4	227.8
Number of farms growing corn	58.9	506.0	121.2
Wheat (acres)	*150.0	610.5	331.0
Number of farms growing wheat	66.5	22.2	80.7

*Decrease.

the former lumbering zones is reminiscent of earlier settlement in the south. While it is desirable to encourage the use of suitable land, the type of crops grown on these marginal fields must be considered in the light of the future. Huge increases in acreage along the poleward boundary of corn cultivation should not be encouraged. Any slight deviation from the normal temperature or rainfall conditions will mean ruin for the farmers involved. This in turn would place an added responsibility upon the state or federal authorities to ease the affected areas during a period of failure.

The considerable amount of crop failure within the zones of rapid or excessive growth illustrates the present lack of knowledge concerning the settlement possibilities of the north. It also demonstrates the inadvisability of extending agriculture into lands which must be considered marginal for climatic or edaphic reasons (Table II). In

TABLE II

PERCENTAGE OF FARMS REPORTING CROP FAILURE

Year	*Cass County*	*Lake of the Woods County*	*Mahnomen County*
1929	27	7	31
1934	10	8	17
1939	3	20	9

contrast to the figures presented for the frontier counties, the state as a whole experienced a considerably smaller amount of failure during these same years. In 1929 only 1.4 per cent of the farms reported were lost, while in 1934 and 1939 the failure was 10.4 per cent and 1.2 per cent respectively. As opposed to the counties under consideration the state returns presented an aspect of farming which is not characteristic of pioneer conditions.

A somewhat similar picture is presented by considering the number of acres reported as failing to make a crop, in relation to the number of acres both harvested and failing (Table III).

TABLE III

PERCENTAGE OF ACRES OF CROP LAND REPORTING FAILURE

Year	*Cass County*	*Lake of the Woods County*	*Mahnomen County*
1929	3.5	2.7	8.4
1934	3.3	2.1	2.1
1939	1.5	5.0	1.9

Failure in the rapidly expanding sections has usually been well above losses experienced by Minnesota as a whole. Only in 1934 was the state average higher than the frontier county loss. A comparison of the figures given for the frontier counties with those for the state indicates a high ratio for the frontier zone. Minnesota in 1929 lost 1.3 per cent of the land planted while in 1934, 12 per cent failed to mature.

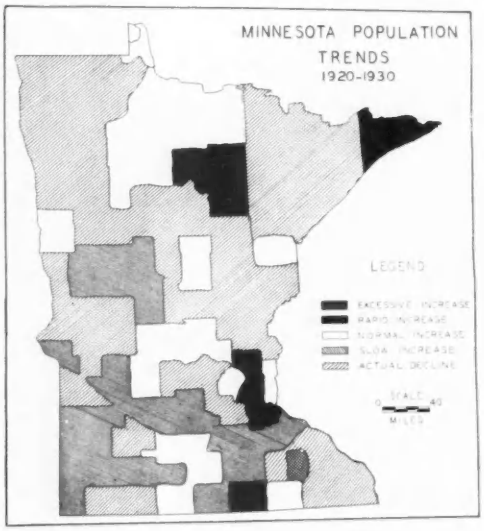


FIGURE 2.—The center of expansion during 1920–30 was confined to the southward extension of the lake district to the northwest of the Twin Cities. A striking change in the trend of rural population trends can be noted by comparing this illustration with the growth map for 1930–40 (Figure 2).

The year 1939 again experienced a 1.3 per cent reduction.

The high figure presented in 1934 was concentrated in the western part of the state and reflects the drought damage of the 1933–34 period. Aside from this single year the frontier counties have consistently led in failures.

PRESENT POPULATION DISTRIBUTION

Today the distribution of population shows closer relationships to the physical landscape than the pattern developed at any time since pioneer days, when the early settlers were closely tied to the master streams in order to export their surpluses and obtain their needed supplies. Later arrivals paid little attention to the drainage pattern. Freedom from dependence upon rivers, and a shifting of settlement from this natural framework to an artificially introduced skeleton of communication lines has been characteristic of the history of population. Railroad construction preceded occupation of the land in most sections. It gave impetus to the use of land lying close to the thoroughfare and encouraged the use of inferior soils which were favorable in location.

Introduction of the motor car has freed rural families from complete dependence upon railroads. Land at a distance from the right-of-way could be utilized as easily as those fields which fronted on railroad property. Thus, while the settlement has shifted from the rivers, and to some extent from the vegetation zones, the automobile has permitted a closer adjustment to the natural environment.

During the railroad era small towns sprang up along the tracks at suitable sites. These centers remain and at present trace the location of many of the moraines. However, the smaller rural villages have stopped expanding and nearly all have experienced a decline in numbers and in importance. Just as the smallest towns have dwindled, so the major cities have slowed in their growth. Only four of the fifteen cities with more than 10,000 population increased as rapidly during this decade as they did during the years prior to 1930. In addition, one, Duluth, actually declined.

Freedom from dependence upon railroads has had a selective influence upon the pattern of population distribution. A wider selection of land, freedom from the crowding of urban development, and a wiser use of the land have resulted from this motor car transportation; this may be observed in the greater number of vacant areas observable on the 1940 map (Figure 3). The areas of abandonment offer no problem for the future. All of these lands have been given up because of the realization of the lack of some essential agricultural requirement. On the other hand, those sec-

tions found along the roads leading to the north are being taken up today. They do afford future sources for settlement trouble, because of the unsuitability of the land for agriculture. These are the sites of farmers who may need financial assistance at a future date.

THE FUTURE

From the evidence presented in the tables it may be assumed that even a small percentage of failure in the acreage of cropland will have a widespread effect upon the economy of the inhabitants. Within the past ten years a large percentage of farms have undergone partial failure. This has become more pronounced as the population has increased and occupied lands unsuited for crop production. A part of the responsibility rests upon the program of crop retirement which has been active in southern Minnesota. With a system of price control and a reduction of certain crops in those areas best suited to their production, marginal lands may be expected to take up a part of the slack. This expansion is being concentrated in those regions which have a rapid or excessive growth in population. The area includes parts of Problem Areas, Numbers 1a and 4. An examination of the physical resources of the areas together with the recommendations for land use may aid in a clearer understanding of the problem. (Area Memorandum No. 39-A: "Description of broad physical problem areas in Minnesota. Revised Sept. 7, 1940." I. J. Nygard, Major Party Chief. Soil Conservation Service, U.S.D.A. Faribault, Minnesota, p. 10.)

Physical Resources.—Lake of the Woods County may be characterized as lying well within the podzol zone. Large sections are covered by peat deposits reflecting the short growing season and the poor drainage of this

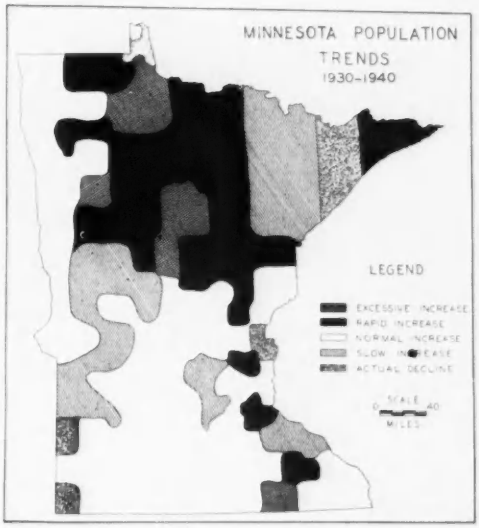


FIGURE 3.—The center of growth in rural population has shifted to those lands lying along the Canadian border. Apparently this expansion is a continuation of the excessive growth area found during the previous decade. It is concentrated on lands which are poorly suited for the agricultural production which is developing in the area.

part of the state. Only a few isolated sites are covered with soils of good fertility. (The U.S.D.A. Soil Conservation Service recognizes five classes of soil fertility in Minnesota. These are graded 1 to 5 in varying degrees of fertility. No Class 1 soils are found in the county.) This combination of unfavorable natural conditions has led to few favorable settlement factors. The only recommended use for land in the county is the introduction of forest and wildlife management to foster the expanding recreational opportunities. The remaining two counties are composed of cut-over lands. Poor drainage and infertile soils are also representative of these rapidly growing districts. Recommended practices are limited to the use of forest products and the retirement of much of the land now under cultivation.

Previous Experiences.—A situation similar to the present discussion existed during the period of rapid population growth in southern Minnesota. Settlers,

unfamiliar with the agricultural possibilities of the land began to occupy Pre-Wisconsin Drift in southwestern Minnesota while they were at the same time abandoning the same geological deposit in the southeastern part of the state. This regrettable situation was not serious during the frontier era because new lands could be found in other parts of the United States. However, the present growth of the north-central section of Minnesota is developing a problem area which may have to be liquidated at some future date. No free land is available for resettlement and consequently these pioneers cannot have a second opportunity without aid from some source.

CONCLUSION

The present population distribution reflects a growing appreciation of the underlying qualities of the land in nearly all parts of Minnesota. A comparison of the 1940 distribution with that of former census years shows that a larger number of people are settled within those areas best suited for our system of agriculture.

In contrast to the present-day pattern, and of more importance, are the trends of future settlement which may be observed at this date. While comparatively few people were involved, the site of the most rapidly expanding population in 1940 is found in that part of the state which is least suited for farming. While agriculture is not advisable within these zones, other resources related to recreation can and should be encouraged. Unfortunately, increasing settlement has been accompanied by a spreading of agriculture not suitable for the region. This is shown in the higher percentage of crop failure that characterizes the three frontier counties considered. If this trend does not halt, or is not discouraged by governmental advice, the 1940 population, which has shown strong relationships to land capabilities will show in the future a population but poorly adjusted to the environment in the region of excessive growth. This will lead to problems of land use which will require state or federal assistance at some future date.

TRENDS IN THE PULP AND PAPER INDUSTRY

Sven A. Anderson

THE paper and paperboard industry plays a prominent rôle in every industrialized country, and its contributions to the economic and social life are truly significant throughout the world. Production of paper is confined to primarily two regions of the world, corresponding roughly to the location of the coniferous forests of northern Europe and North America. In 1933, for example, Norway, Sweden, and Finland produced almost as much mechanical pulp as the rest of Europe combined, and nearly one-fourth of the world's total requirements. In the same year, these countries accounted for more than one-third of the world's total production of chemical pulp and about one-eleventh of the world's output of paper.

In the United States, according to the figures of the United States Census Bureau, the industry is the ninth largest in the country as regards the number of wage earners employed. With respect to the value of products manufactured, it ranks tenth, and it ranks eighth on the basis of expenditures for raw materials. Through the years, sweeping technological improvements have been made which have greatly increased the output per worker. It is difficult, however, to point to any technological unemployment in the industry as a whole, for in 1940 the number of wage earners in the industry was 12 per cent greater than it was in 1929.

In 1938, the most recent year for which complete statistics are available at this time, the United States consumed 13,388,000 tons of paper, an average of 206 pounds per person. The larger part of this paper, with the exception of newsprint, was manufactured in the United States. The American mills, however, drew heavily upon Canadian and Scandinavian sources for wood pulp, and also upon Canada for considerable quantities of pulpwood. Normally, about 50 per cent of the wood used to meet the paper mill requirements of the United States is imported, 10 per cent of it in the form of pulpwood, 20 per cent in the form of wood pulp, and 20 per cent in the form of paper.

From Rags to Wood Pulp

Papermaking is a very old industry, dating back approximately 2,000 years. It started in China, whence it spread very slowly to northwestern Europe via Samarkand in Russian Turkestan, Baghdad, Egypt, Morocco, and finally Spain and southern France. The art reached Germany in the thirteenth century and England in the fifteenth. It was introduced into the United States in 1690, when the first mill was built in Germantown, Pennsylvania, by four partners, one of whom was William Rittenhouse who had mastered the trade in Germany.

The Chinese used the inner bark of the mulberry tree as the raw material for their paper. In Samarkand, the absence of the mulberry tree led the Arabs to use linen fibers. In Europe, rags—both linen and, later, also cotton—constituted the chief raw material; this was also true of the early phases of the industry in this country.

In time, however, the supply of rags became totally inadequate for the demands of the rapidly expanding industry, both in Europe and in this

country. Numerous advertisements appeared, some appealing to the "support home industry" sentiment, offering to buy rags. In the 1770's the following item appeared in a Boston, Massachusetts, newspaper: "The Bell Cart will go through Boston before the end of next month to collect rags for the paper mill at Milton when all people that will encourage the paper manufacture may dispose of them." The prices paid for rags rose steadily, and substitutes were eagerly sought. Experiments were made with a large number of vegetable fibers, such as straw, grasses, corn husks, ferns, nettles and many others, but straw was the only fiber used on a commercial scale. A straw mill was erected at Chambersburg, Pennsylvania, in 1851, and today a few mills engaged in the production of paperboard (strawboard) are still using limited quantities of straw as a raw material.

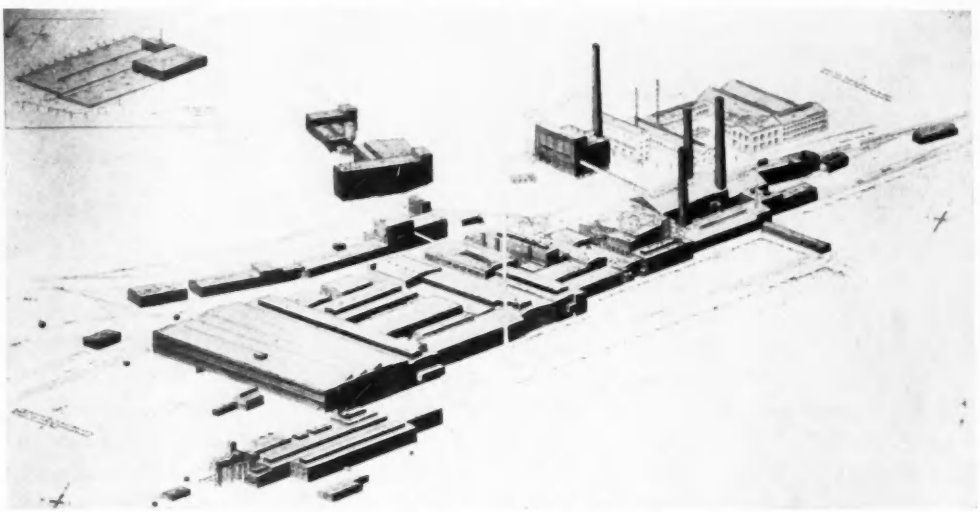


FIGURE 1.—The layout of a pulp and paper mill located in the state of New York.

Although wood had long been considered as a possible source of paper fiber, it was not until 1840 that a method was found in Europe whereby wood could be made into a pulp suitable for the making of paper. By this new method pulp was produced by grinding the wood with a roughened stone. The ground pulp was inferior, however, to the traditional rag pulp, and for some decades it was used largely as a filler mixed with rag pulp. In this country the first groundwood pulp was made in Curtisville, Massachusetts, in 1866. Groundwood or mechanical pulp is still of great significance in the industry, especially in the manufacture of newsprint. In the production of newsprint and wallpaper it is used in the proportion of 80 per cent to 20 per cent sulphite (or less); it is also used extensively in the production of container board, building board, wrapping and low grade tissue paper.

Paper is made from a carbohydrate, cellulose ($C_6H_{10}O_5$), which is the chief constituent of all leafy green plants. Coniferous wood consists roughly of 50 per cent cellulose, 3 per cent lignin, 15 or 16 per cent other carbohydrates and the balance is extraneous materials. The problem confronting the papermaker is to isolate the cellulose by removing the lignin and the other extraneous substances. The first chemical

process in pulpmaking was the soda process which consisted of cooking wood chips in a caustic-soda liquor whereby some of the extraneous materials were dissolved. By 1865 soda pulp was produced on a commercial scale in this country.

Next came the discovery of the sulphite-pulping process in which the separation of the cellulose was achieved by cooking the wood chips with a solution of sulphur dioxide, with the addition of calcium bisulphate to dissolve the lignin and other substances.

The sulphate method is essentially a modification of the soda process. Instead of the soda ash, the cheaper salt cake, or sodium sulphate, was used. The salt cake produces a milder cooking liquor, and not only were the costs reduced but a pulp with longer and stronger fiber was obtained. The new process permitted the use of sawmill refuse, of which there were great quantities in the forests of Sweden, Finland, and Norway. The Swedish mills of the 1890's have been referred to as "centers of pilgrimages" for American paper manufacturers who were determined to satisfy themselves that the process worked before putting any money into it. (Paper Trade Journal, November 28, 1940, Part II, p. 32.) The conservatism on the part of the United States' papermakers gave Canada the opportunity to build the first sulphate mill in North America in 1907.

FIGURE 2.—Pulpwood on its way to the mill. Pulpwood may be floated to the mill or may arrive by railroad or truck, depending upon where the mill is situated.

DIVISIONS OF THE INDUSTRY

The paper and paperboard industry may conveniently be divided into three phases. First comes the production of pulp which in turn may be subdivided according to the type of process used. The various processes have been described above. Mechanical pulp or groundwood is the product of a grinding process. Soda pulp, sulphite and sulphate are products of chemical processes.

The relatively small quantities of soda pulp produced today are virtually all mixed with bleached sulphite to make magazine and book paper. Sulphite has a wider use than any other type of pulp. Unbleached sulphite is used in the production of newsprint and other cheap printing paper, as well as wrapping, tissue, and other paper, in which whiteness is not essential. Bleached sulphite is used in the production of book, writing bond and similar types of paper. Newer, highly purified grades are used in the rayon, cellophane, and plastic industries. Unbleached sulphate, or kraft, pulp is used in making paper in which strength, rather than color, is the prime consideration, such as brown wrapping paper, bags, container board, and towels. At the present time relatively small quantities of kraft pulp are bleached, but the trend points toward the use of increased quantities of fully bleached sulphate in mixture of highgrade bond and writing paper.

Papermaking, as distinct from the production of pulp, is generally classified according to the uses to which the paper is put. Among these vari-

ous classes of paper, as may be seen from the accompanying table, paperboard (chiefly for containers), wrapping paper, and newsprint occupy prominent positions.

TABLE I

PRODUCTION OF PAPER IN THE UNITED STATES

In Selected Years

(Adapted from Paper Trade Journal, Feb. 20, 1941, p. 35)

(In 1,000 Tons)

Grade	*1929*	*1937*	*1939*
Paperboard	4,451	5,802	6,105
Wrapping Paper	1,606	2,053	2,239
Book Paper (Uncoated)	1,498	1,521	1,535
Newsprint	1,409	976	954
Building Paper	659	608	646
Tissue Paper	388	540	666
Writing Paper	608	582	595
Groundwood	521	518	541
All Other Paper		237	213
Total	11,140	12,837	13,493

GEOGRAPHICAL SHIFT IN PULP PRODUCTION

The production of pulp is closely tied up with the forest resources of the world, since wood, and particularly coniferous wood, is the most important raw material. Today, commercial pulp production is confined to regions which can fill the following requirements:

1. Timberlands located not too far from the plant.

2. Conditions which permit the floating of the pulpwood to the mills, since railroad transportation costs are prohibitive.

3. Availability of great quantities of low-cost power.

Virtually all the coniferous forests are found within the temperate belt of the northern hemisphere. In Eurasia, large areas are found in Scandinavia, Finland, and the east Baltic regions, parts of Germany, Russia, and Siberia. Because of their inaccessibility, the Siberian sources as well as those of the greater part of European Russia are at present of slight economic consequence. In North America, the coniferous belt includes the United States and Canada.

The area within the United States may be divided into five sections, namely, the Northeastern, the Lake, the Southeastern, the Rocky Mountain, and the Pacific Coast sections. The oldest and most important sections are those of the Northeastern and the Lake regions. Although in many parts the supply of pulpwood is less abundant than it once was, the proximity to an unsurpassed market for paper affords a marked advantage to these regions. In addition, Canadian pulp, mostly of the much desired spruce variety, from Ontario, Quebec, and New Brunswick, is available in large quantities. Many of the mills on the eastern seaboard receive their supply of pulp from Scandinavia and Finland. In the Rocky Mountain and Pacific Coast regions, the stands are Douglas fir and, in some parts, also spruce.

In early days, the American pulp industry was largely confined to New England and the state of New York. The extensive native stands of spruce in that part of the country afforded an abundant source of excellent groundwood, as well as sulphate pulp. But before long the industry began to move westward to Wisconsin, Michigan, and Minnesota, and then farther west to Washington and Oregon. The great stands of spruce and balsam of the northern parts of the Middle West, as well as the formidable stands of hemlock and firs of the Northwest, beckoned. But both the East and the Middle West are still important producing regions. Maine and New York still rank high in the production of both pulp and paper, as indicated by the accompanying tables. In the case of Massachusetts and Connecticut, on the other hand,

FIGURE 3.—Typical storage pile for pulpwood adjacent to a pulp mill. Most of this wood was shipped by rail.

the former has now only three pulp mills and the latter none.

TABLE II

LEADING WOOD PULP PRODUCING STATES, 1937

(*Source*: U. S. Census of Manufactures)

State	*No. of Establishments*	*Value of Products*
Washington	19	$48,411,890
Wisconsin	27	30,292,863
Maine	25	28,890,516
New York	39	20,145,208
Virginia	9	18,134,060

SHIFTS IN NEWSPRINT PRODUCTION

Economical newsprint production requires that both pulp and paper be produced in the same plant. The newsprint branch of the paper industry resembles the pulp industry in that proximity to the forest (geographic or economic) is essential. The same factors which brought about the geographical shift in the production of pulp have therefore also influenced the allocation of newsprint mills in recent years. Other factors have been the removal by the United States of the duties on newsprint in 1911 and 1913, and the promotional activities on behalf of newsprint and pulp by the Canadian Government. The reduction of the United States tariff was largely due to the efforts of the American press. Ever since the formation of the International Paper Company, in 1898, the American newspapers had advocated government action against the "paper trust." In these campaigns, the conservation argument played a prominent rôle, as it had wider appeal than the

TABLE III

UNITED STATES IMPORTS OF WOOD PULP AND NEWSPRINT IN 1938

Country	*Mechanical Pulp*		*Sulphite*		*Sulphate*		*Newsprint*	
	Tons	*Per Cent of Total U. S. Imports*	*Tons*	*Per Cent of Total U. S. Imports*	*Tons*	*Per Cent of Total U. S. Imports*	*Tons*	*Per Cent of Total U. S. Imports*
*Canada	122,216	76.7	252,529	26.3	82,173	15.9	1,963,436	86.3
Sweden	19,537	12.3	437,033	45.6	350,559	67.6	72,554	3.1
Finland	16,872	10.6	170,368	17.7	71,668	13.8	151,139	6.6
Norway	514	.3	57,481	5.9	12,370	2.4	.....	....

*Canada also contributed 9,405 tons of soda pulp, which was the total quantity of that product imported in 1938.

price of newsprint. It was held desirable for the nation to slow down American deforestation by importing wood or wood pulp from other countries. After 1913, Canadian production of newsprint rose steadily. In that year, it was about one-third that of the United States; it passed the United States figure in 1925, and in 1940 it was more than three times that of the United States. It was inevitable that in this development of Canadian forest resources, American interests should play a prominent rôle. To illustrate, with the exception of the output of a small mill in Maine, all the newsprint produced by the large International Paper Company is accounted for by the Canadian mills of the company.

TABLE IV

PAPER PRODUCTION OF CANADA

In Selected Years

(In short tons)

	1929	*1937*	*1939*
Newsprint	2,725,331	3,673,886	2,296,597
All other paper	471,818	671,475	673,905
Total	3,197,149	4,345,361	3,600,502

The preponderance of newsprint production in Canada is clearly brought out.

PRODUCTION OF OTHER PAPER

The geographic shift which has been characteristic of the pulp and newsprint industries has not occurred to the same extent in the manufacture of paperboard and specialty paper. In this branch of the industry, the market factor has been the determining influence, with the result that eastern United States has continued to occupy a prominent position. Thus, New York had 119 paper mills in 1940 and Massachusetts 88. Other leading states were Michigan, Pennsylvania, Wisconsin, Ohio, and New Jersey. Many paper mills do not produce their own pulp, but purchase it from various sources. In normal times the mills of eastern United States rely very largely upon imported Canadian, Scandinavian, and Finnish pulp for their requirements.

TABLE V

LEADING PAPER PRODUCING STATES, 1937

(*Source*: U. S. Census of Manufactures)

State	*No. of Establishments*	*Value of Products*
New York	115	$110,550,936
Wisconsin	46	97,933,597
Michigan	46	92,418,197
Ohio	48	81,552,239
Pennsylvania	46	77,060,091
Maine	24	70,084,878
Massachusetts	72	68,599,767

TIE-UP BETWEEN PAPER AND POWER

The great quantities of power required for the production of pulp and newsprint led several firms to engage in large-scale generation of electric power. Then followed the necessity of marketing surplus energy and the subsequent formation of distributing systems. This development was ultimately tied up with the exhaustion of the available pulpwood resources and the migration of the plants to newer regions. In many instances, not only in the United States but also in Canada, nothing would remain but an obsolete mill and the power plant. The latter represented an investment that could be utilized. Some concerns sold their power sites, others branched out into the power field, but the manufacture of pulp and paper was moved to another location, where the pulpwood supply remained ample. Thus, in time, the International Paper and Power Company, for example, came to control 82 per cent of the New England Power Association. In 1931, the St. Regis Paper Company held 16.6 per cent of the Niagara Hudson Power

Company. In 1940, in connection with the reorganization of the Abitibi Power and Paper Company, a Canadian corporation, a commission appointed by the Ontario government to investigate the company, reported that "the Abitibi Company owns power plants at Iroquois Falls, Island Falls, and Twin Falls on the Abitibi River; at Smooth Rock Falls, Sturgeon Falls, Crystal Falls, Kakabeka Falls, and Port Arthur. . . . It develops so much power at some cities, such as Island Falls, that it is cheaper for the company to leave the street lights burning all day than to install switches and pay a man to turn them off." The International Paper and Power Company built up the International Hydro-electric System and also gained control of the New England Power Association. After 1935, in order to avoid registration by the parent company and the International Paper Company under the Public Utility Holding Company Act, the parent company divested itself of its public utility holdings. Such registration would have subjected the company, including its paper making subsidiaries, to governmental supervision designed for public utility holding companies and not for concerns engaged in manufacturing, such as the production of pulp and paper. A separation of power utility operation from the activities of the International Paper and Power Company was thus achieved. Similar action was also taken by other corporations in the paper industry which had become interested in electric power.

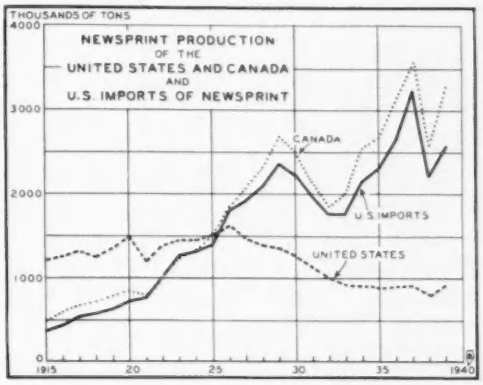


FIGURE 5.—Newsprint production of the United States has decreased during the last twenty-five years, while that of Canada has increased markedly. Virtually the entire Canadian output is exported to the United States. (Source: U. S. Dept. of Commerce and "Commodities in Industry," 1941.)

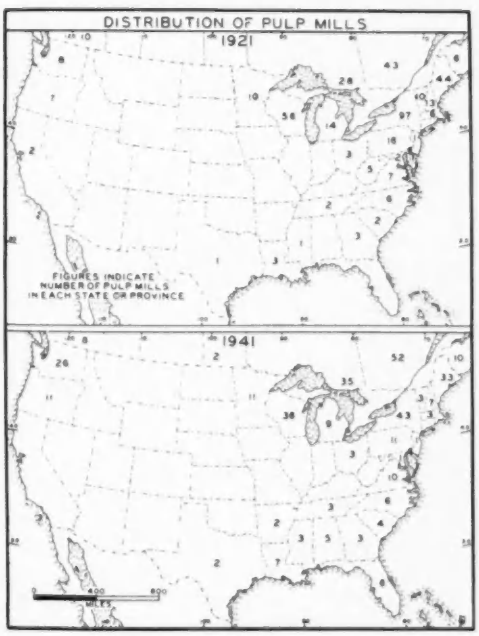


FIGURE 4.—During the last quarter century the distribution of pulp mills in North America shows a pronounced shift from New England and the Middle Atlantic states to Canada and, to some extent, southern United States.

DEVELOPMENTS IN THE SOUTH

Reference has already been made to the high point of development to which the sulphate process had been brought in Sweden in the 1890's. American engineers and paper manufacturers who had traveled in Sweden and had seen the use to which wood waste was put in that country, envisaged great possibilities for the yellow pine regions of southern United States as producers of sulphate pulp. Several testing plants

were built, but the results obtained did not measure up to expectations. Finally, the first sulphate mill in the United States was built at Roanoke Rapids, North Carolina, in 1909, in which kraft pulp was made from southern yellow pine or slash pine. But considerable doubt remained for some time in the minds of industrialists as to the adequacy of the supply of wood to warrant the construction of expensive modern mills. After 1930, however, great strides were made in the South.

For this rapid development, Dr. Charles H. Herty, one time professor of chemistry at the University of North Carolina, was chiefly responsible. Dr. Herty's researches brought out not only that there was enough pine for a flourishing industry, but also that a steady supply could be maintained. Dr. Herty also showed that the high resin content of southern pine did not preclude its use for pulping purposes. High yields of resin acids and turpentine are obtained from older trees, while the resin contents of the sapwood are so low as to be negligible. Consequently, trees under ten years of age are used for pulpwood in the South while in the North they are twenty-five years old or more. If other factors are the same, such as the quality of the wood fiber, this would mean that a pulp mill in the South needs a much smaller forest reserve from which to draw its pulpwood than does a mill in the North. The first newsprint mill in the South, located at Lifkin, Texas, began production in 1940. While the technical problems appear to have been solved, the ability of southern mills to compete successfully with an established Canadian industry, with a time-tested raw material and a high rate of productivity, necessarily remains to be demonstrated.

GEOGRAPHY OF NEW ENGLAND SOILS

A. B. Beaumont

SCIENTIFIC classification of New England's soils began about a hundred years ago with the pioneer work in this field by the pioneer geologists of that time, notably Charles T. Jackson and Edward Hitchcock. The year 1941 is noteworthy for geologists and soil scientists as the centenary of the publication of Hitchcock's monumental report on the geology and soils of Massachusetts. Geologists, particularly, have a right to be proud of Edward Hitchcock on the occasion of this gathering of scientists at Durham, because he was one of the founders of the American Association for the Advancement of Science.

Science has marched onward since the days of these pioneers. Soil science has cut the apron strings that held it to its mother, geology, in its tender years and has made a place for itself in the family of sciences. The important agency of soil formation in this region, which Jackson and Hitchcock, in line with the leading thought of the time, considered to be flood, or diluvial, action is now accepted to be glaciation; the genesis of the extensive northern gray soils, now generally called podzols, is now known to be due to climatic and vegetational conditions; and, although much remains to be done, the boundaries of our knowledge in this field are steadily being pushed outward by the efforts of scores of geologists, geographers, and soils workers.

Some general considerations of the geography of New England soils will first be presented. First, consider the podzols and their distribution. These soils, with their gray, or bleached, A_2 horizon and their coffee-colored layer of *orterde* or *ortstein*, are the resultant of a cold climate, generous precipitation, and a coniferous forest cover. The character of the soil also is a factor in the formation of podzols, particularly the rate of formation. True podzols are commonly found at elevations above 1,500 feet in western Massachusetts and at decreasing elevations northward through Vermont, New Hampshire, and Maine, occurring at about 1,000 feet in middle New Hampshire, at about 750 feet in northern Vermont, and at 500 feet or lower in northern Maine. However, some of the best developed podzols of the region occur on Cape Cod at elevations below 100 feet. Here the highly quartzose character of the soil is an important factor in the podzolization process. The remaining soils of this region consist of the brown podzolic soils typified by the Gloucester series; the gray-brown podzolic, represented by Orono; Wiesenboden or meadow soils; and bog soils. Podzolic soils differ from podzols in not having a well-defined bleached A_2 layer.

New England soils are mostly upland till soils derived from ground and terminal moraines. According to soil surveys made by or in coöperation with the U. S. Bureau of Soils 67.5 per cent of Massachusetts soils, 80.1 per cent of Vermont soils, and 86.9 per cent of the soils of Grafton County, New Hampshire soils, are till soils. These figures include land types classed as rough stony, rough mountainous, and rock outcrop, all of which are considered non-agricultural. It appears reasonable to estimate that 80 per cent of New England soils are

from glacial till, and that 50 per cent of the soils of this group are or were so stony as to make cultivation difficult. These are the kind of soils that dismayed the scouting party sent out by Governor Winthrop of Massachusetts and caused them to report that most of the land of what is now Worcester County was not fit for human settlement. As Hulbert so well points out in his book on the influence of soil on American history, it was the meadow land, terraces and outwash plains of the valleys, that was highly prized by the New England pioneers.

Both Jackson, in his report on the geology of Maine, 1838, and Edward Hitchcock, in his report on the geology of Massachusetts, 1841, called attention to the close relationship existing between the soil and the bedrock geology, but both observed that the rock material had been moved somewhat in a southerly direction from its starting point. Jackson in his third report on the geology of Maine stated that the line of movement was South 15 degrees East. Hitchcock, discussing soils, wrote in his report: "In general, if any one wishes to know where to find them, let him look at the Geological Map which accompanies this report, and he may conclude that the different soils cover those portions of the surface that are represented as occupied by the rocks from which they are derived. There is one circumstance, however, that prevents us from considering the boundaries of the rock formations as perfectly coincident with those of the soils. Diluvial action has removed nearly all the loose covering of our rocks in a southerly direction; often several miles; and more or less mingled the soils from different formations." The soils of New England, generally, are pedologically immature and not far removed in mineralogical composition from the parent rock material.

Thus, the granites and gneisses of southern and eastern New England have given rise to the extensive and agriculturally important Gloucester, and the less extensive and less important Plymouth, groups of soils and their outwash analogues the Merrimac-Hinckley and Carver-Dukes groups. Farther north and at higher elevations are found the podzol counterparts of these series—Hermon, a till soil; Colton, corresponding to Merrimac; and Danby, corresponding to Hinckley. Plymouth soils are developed on the terminal moraine of Plymouth County and Cape Cod. Some of the Plymouth soils are podzolized, and Dukes, an outwash from Plymouth, is podzolized.

The proper names just used in designating soils are the names of soil series. This category in soil classification is the next above the soil type, which involves the textural character of the soil. The soil series is comparable to the geological formation, and, like the latter, takes its name from the locality where it is first recognized.

South of the terminal moraines of Cape Cod and the nearby islands are level to undulating areas of outwash sandy materials similar to the coastal plain of Long Island. Merrimac is the most important soil of this area. Tisbury, an associated series, closely resembles Merrimac, but is somewhat heavier and deeper. Dukes also resembles Merrimac, but is podzolized. The better soils of this area are used for strawberries, turnips, market garden crops, and dairying.

In southeastern Massachusetts and northeastern Rhode Island is an area of soils developed largely from shales, slates, sandstones, and conglomerates of the Narragansett Basin. This area is designated Coloma-Newport. How-

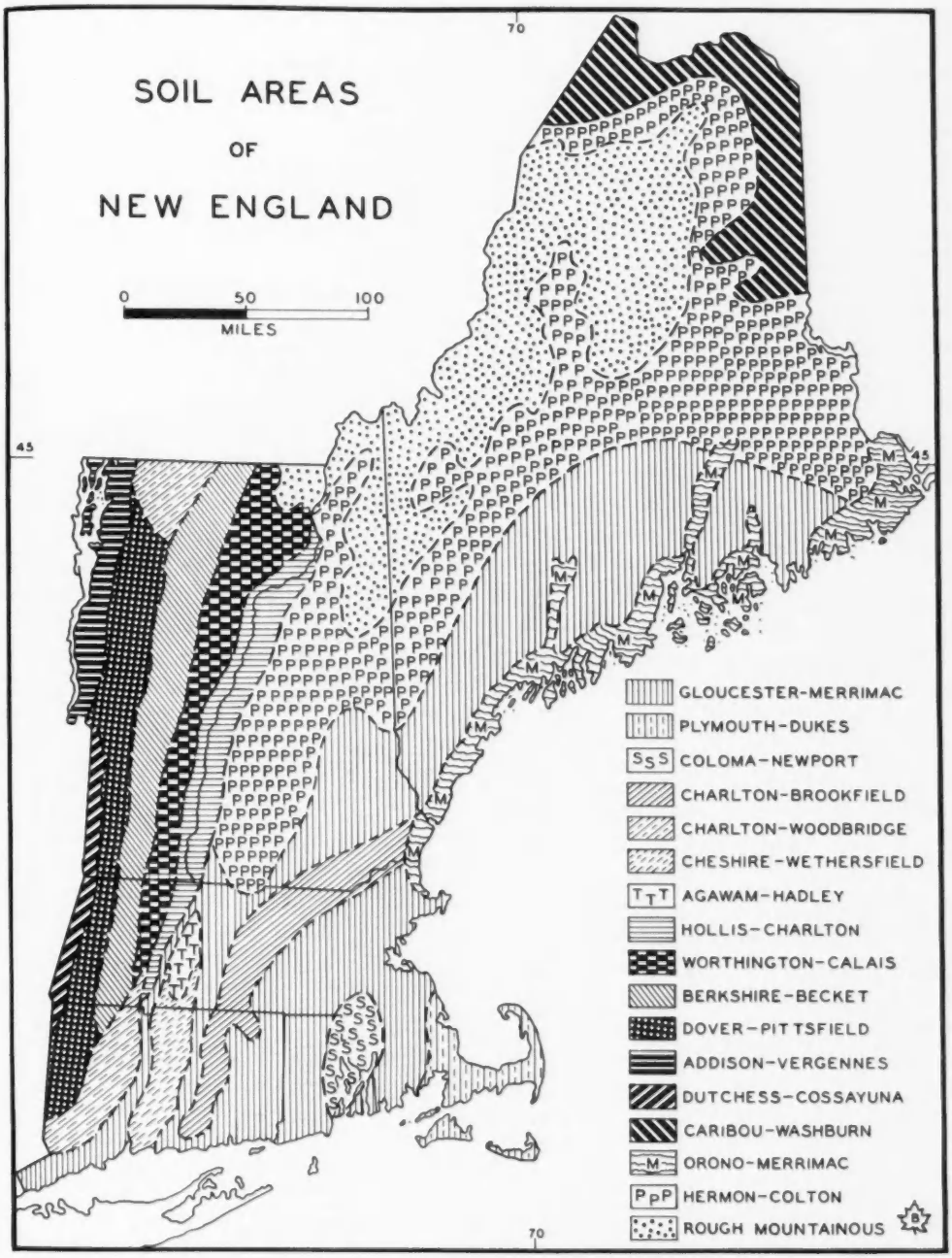


FIGURE 1.—The distribution of soil families in New England reflects its geological structure and physiographic history, and indicates the pattern of agricultural practice and farm economy. Like the parent materials from which they are derived, the soils are richly diversified and form the foundation for a wide diversity of products, within the limits set by the climate of the region.

ever, Coloma, the important till soil, is now thought to be an incorrect correlation for this area, and these soils will probably be recorrelated as St. Riga. Where not too stony, Coloma soils are good for general farming and fruit.

Coloma soils are used considerably for market gardens because of their proximity to Providence but the adaptation is usually poor. Newport, an associated series, is somewhat better. Warwick is an associated outwash series. In the first survey of Rhode Island, Miami, developed on till containing some limestone, was incorrectly mapped in that state. This has now been recorrelated as Narragansett. Miami is not now mapped west of Ohio.

From the schists and quartzites of central Massachusetts and eastern and western Connecticut come the deeper, more compact and less stony Charlton soils, and the shallower and stony Brookfield soils having a pronounced ocherous brown color; from the schists and slates of western Massachusetts, the heavier Woodbridge soils. The latter soils have been mapped also in northeastern Massachusetts, New Hampshire, and northwestern Vermont. The soils are used for general farming, fruit growing, and forestry. Charlton soils are among the best upland soils. Hollis, a shallow Charlton, is found in area 5_1.

Scattered through the Gloucester and Charlton areas, and particularly in central Massachusetts and southeastern New Hampshire there are drumlins and drumloid hills. More than 300 drumlins have been mapped in Worcester County, Massachusetts. Most of the drumlins with podzolic soils have been mapped in the Paxton series, while similar podzolized soils occurring farther north have been classified as Marlow. The drumlins of the northeastern corner of Massachusetts have been mapped as Woodbridge. Drumlin soils are of value particularly for grass culture.

On the sandstones and shales of the Triassic rocks of the lower Connecticut Valley have developed the important reddish Cheshire and related soils. Cheshire is a ground moraine till soil; Wethersfield occupies the drumlins of this area; Chicopee and Hartford are outwash soils of smooth terrain; and Hampden and Manchester outwash of hummocky topography. This area is streaked with eruptions of trap rock which has given rise to the relatively unimportant Holyoke series. In the upper part of the Valley from about Springfield northward are found large acreages of Merrimac, Agawam, a high stream terrace, and Hadley, a fine bottom soil, used especially for tobacco, onions, and asparagus; and Suffield, formed on glacial lake sediments, and important for grass culture.

On both sides of the upper Connecticut River with a tongue extending into Massachusetts is an elongated area designated Hollis-Charlton. The Hollis series includes shallow brown till soils derived from fine grained micaceous schists. They resemble Charlton soils and where not too shallow, stony, or steep, are good agricultural soils. Bernardston soils, derived from schists, shales, and slates and often containing chips of phyllite are found in the southern part of the area, and also in the Charlton-Paxton area, and are good for general farming and orcharding. A lighter colored Hollis has been mapped in the eastern part of Massachusetts. Colrain soils are also found in the Vermont side of this area.

Going west, the Worthington-Calais area extending from the Western Highlands of Massachusetts to northern Vermont is next encountered. The soils of this area have been influenced by limestone. Worthington and Calais are till soils derived from schists and impure limestone and are important agricultural soils. Worthington soils are found in the southern part of the area, Calais in the northern, and Greensboro is associated with both. Colrain

and Shelburne, also having some limestone influence, are important orchard and dairy soils found in the southern part of the area.

Extending from the southern Berkshire hills from about the Connecticut-Massachusetts line up through the Green Mountains to the Canadian line is a belt of hilly to mountainous land designated on the map as the Berkshire-Becket area. Much of this area is mapped as Rough Stony Land and is unsuited to agriculture. Schists, gneisses, and coarse-grained granites are the parent rock materials. The soils are strongly acid and mildly to moderately podzolized. Hermon soils, the podzol equivalent of Gloucester, are important in this area.

The Dover-Pittsfield area extends from western Connecticut through the Berkshire Valley up to the Champlain district. The soils are developed from the Stockbridge limestone or from till containing limestone, slate, schist, gneiss, and quartzite. They are important agriculturally. Dover soils are brown podzolic, are derived from limestone till or from the bedrock and are found in Connecticut and Massachusetts. Pittsfield soils are gray-brown podzolic, are from till containing limestone and non-calcareous rocks and are found in Massachusetts and Vermont. Other important limestone soils in this area are Lenox, Stockbridge, and Madrid.

An important area of agricultural soils suited particularly to crops useful in dairying is the Champlain Valley of northwestern Vermont. The soils are developed on sediments washed mainly from limestones and are more or less calcareous. Addison, the most extensive and the best drained soil of the group, has a brown topsoil and a gray subsoil. Vergennes is grayer and less well drained. Both soils are highly calcareous. Sheldon is Vergennes with a sandy overwash. St. Albans is another series of this group.

Brief mention should be made of the narrow strip of Taconic Mountain land on the western edge of Massachusetts and southwestern boundary of Vermont. These soils are derived mainly from the slaty Berkshire schist of that section. Owing to steep slopes and shallow soils the area is of little agricultural importance. Cossayuna and Nassau, also found in this area, contain some limestone and are better soils than the Dutchess.

Swinging northward, the important Caribou soil area is seen. The soils of this area are famous because of their extensive use for, and high adaptability to, potato growing. They are derived mainly from shales and limestone. Caribou loam is the most important type. Associated soils include Washburn, imperfectly drained; Easton, poorly drained; and Aroostook, a first bottom soil.

Coming down to the Maine coast, we find the Orono-Merrimac area which marks the submerged coast line at the close of the glacial period. The Orono series consists of gray imperfectly to poorly drained, neutral to alkaline, heavy soils derived from marine clays. They are best suited to grass culture. Considerable Merrimac is mapped in the area. Soils developed on sand over clay are mapped as Adams.

The large irregular area extending from southern New Hampshire through central Maine and designated Hermon-Colton is not well known. Information used in outlining it was obtained particularly from the Agronomy Department of the University of New Hampshire and from the generalized map published by the Division of Soil Survey, U. S. D. A. There is considerable Marlow, podzolized drumlin soil, in the southern part of the area; also

some Becket. Berkshire is found in the western extension; also Woodbridge, Charlton, and Sutton. Much of this area, particularly in eastern New Hampshire and in Maine is Rough Mountainous and unsuited to agriculture.

The final area is that of northern New Hampshire and northwestern Maine designated as Rough Mountainous. This area, like the Maine woods which constitute its principal cover, holds many secrets, including those of the soil. Hermon and Berkshire soil materials are known to exist in the New Hampshire portion and most likely these materials would be found to be extensive in the Maine portion of the area since granites, schists, and slates are known to be present there. This area is almost wholly non-agricultural.

Only the more important of the hundred-odd soil series that have been mapped in New England have been mentioned. With increasing activity in soil survey in this region, the number of series is increasing. Most soil series include two or more textural members. The series and textural designations together constitute the type, for example, Gloucester loam.

Brief mention should be made of New England's extensive peat resources, which are as yet largely unexplored and undeveloped. The impounding of water in thousands of basins, caused by glacial deposits in drainage channels, created conditions favorable to peat formation. The more common types of peat found in the north temperate zone, namely woody, reed or sedge, sedimentary, and moss peat, are present in New England. Woody peat is the most abundant type in the region. Moss peat is found in limited amounts in the northern part of the area.

Peat deposits vary in size from less than an acre to several hundred acres and in depth from 1 or 2 feet to 30 or 40 feet. Many of them are too small for profitable commercial development, but have potential agricultural value. Connecticut has approximately 50,000 acres of peat, Massachusetts has over 300,000 acres, and the remainder of the area probably contains two or three times as much as these two states combined. The woody, and reed and sedge peats and mucks are used to a small extent for cultivated crops and more extensively for hay. The valuable cranberry crop of southeastern Massachusetts is grown mainly on woody peat bogs. Woody peat is also used as an amendment in greenhouse, nursery, garden, and lawn soils. Moss peat is valuable for a variety of agricultural and commercial uses.

The geologist is perhaps most interested in soils as they reflect the parent rock material and the processes by which they are formed. The geographer, somewhat like the agronomist, is perhaps most interested in the use of soils and their distribution. A well trained soil surveyor can multiply soil types almost *ad infinitum*, but well trained agronomists and geographers have difficulty in interpreting many of the types in terms of specific, differentiated land use. But that brings up another important topic that is without the scope of this article.

DECLINING SUGAR PRICES AND LAND UTILIZATION IN THE BRITISH LESSER ANTILLES

Otis P. Starkey

THE Lesser Antilles form a crescent-shaped chain of volcanic and coral islands extending from Puerto Rico to Trinidad. About 1650 their humid, fertile plains, tilled by Negro slaves, began to yield the sugar which brought fortunes to the slaveholders. Upon this agricultural foundation arose a wealthy landed aristocracy which was influential enough to be a leading power in the English Parliament. For nearly two centuries the influence of this planter class waxed and waned until emancipation and the fall of sugar prices finally brought about its decline.

The loss of West Indian political influence was most clearly indicated by the abolition of the British slave trade in 1807 and the emancipation of the slaves in 1834. Although some compensation was paid to the planters for their slaves, emancipation was, for most, a severe economic blow, and for the others, an economic *coup de grace*. Nevertheless, this period of stress was not wholly disadvantageous to the planter class. The survivors were forced to improve their methods of farming and to erect more efficient sugar mills. Thus, after an unhappy decade of readjustment, the best of the planters had retrenched so that they were able to make moderate to good profits until the 1870's when the influx of beet sugar started a severe price decline.

Sugar Production in 1875

In 1875, sugar cane was still the major cash crop throughout the Lesser Antilles. The planters' methods of cultivation and manufacture were but moderately efficient: they rotated sugar cane only with ground provisions, maintained the fertility of their fields by heavy applications of pen manure, and conserved soil moisture by cane-trash mulches. Their canes were crushed by three-roller windmills, and even the best of these were able to extract only half the sugar in the canes. The cane juice was boiled down, crystallized into muscovado sugar, and shipped in hogsheads to the refiners of the United States.

This method of sugar production was so simple that many of the landholders could spend most of their time in England without reducing greatly the income from their property. Although increasing competition from Cuban and beet sugars had aroused some apprehension among the planters, increasing sugar consumption had prevented any disastrous price decline. Thus the sugar plantations remained profitable—in fact, so profitable that one Barbadian official was able to testify in 1895: "My father brought up his eight children and sent me to Oxford on an estate of only 100 acres." (*Colonial Reports: Barbados*, 1897.) No wonder the planters were, on the whole, contented with themselves and their lot!

Price Decline

After 1873, the planters' complacency received a rude jolt from the price decline caused by the flood of bounty-fed and tariff-protected sugars. From 1840 until 1872 London sugar prices had stayed above 30 shillings per hundredweight; then prices sagged until they

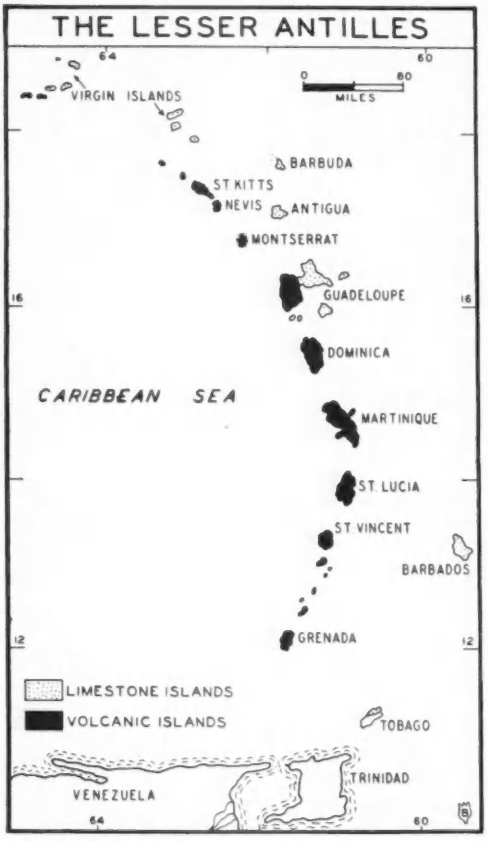


FIGURE 1.—Location and structure of the Lesser Antilles.

became steady at around 25 shillings from 1878 to 1882. Another price decline established a new low of 13 shillings in 1886. Several periods of rising prices followed, then prices dropped to 9 shillings in 1897. Prices recovered somewhat thereafter but sugar was not quoted above 16 shillings until the War Boom of 1915–20. After 1920 prices dropped sharply and reached 5 shillings in the early 1930's.

Figures 2 and 3 show that this price decline caused important changes in the amount of sugar production. At first, the planters intensified their cultivation so as to maintain the total value of their crop by increasing its quantity. However, about 1887–90, the appearance of pests and cane diseases and the continued price decline discouraged further intensification; consequently the planters began to abandon sugar cultivation.

Throughout the Lesser Antilles, the planters sought new crops to replace the hitherto dominant cane. The success of this search in each island is indicated approximately by the decline of the sugar exports (Figures 2, 3, and Table I). Those islands which could find alternative crops, adopted them. However, the planters of St. Kitts-Nevis, Antigua, and Barbados had such discouraging experiences with alternative crops that they again turned their attention to sugar. Let us consider briefly how each island's environment influenced the relative importance of sugar during this period of falling prices. We shall discuss first those islands which changed most successfully to other crops.

TABLE I

THE CONTRIBUTION OF SUGAR PRODUCTS TO THE TOTAL EXPORTS*

Island	*1882*	*1890*	*1896*	*1914*	*1928*	*1938*
Grenada	11%	0	0	0	0	0
Dominica	....	43%	15%	0	0	0
Montserrat	82%	....	63%	0	0	0
St. Vincent	75%	....	42%	0	19%	7%
St. Lucia	94%	....	74%	44%	45%	50%
St. Kitts-Nevis	99%	99%	96%	50%	82%	98%
Antigua	99%	98%	94%	89%	97%	95%
Barbados	99%	99%	97%	93%	95%	97%

*Sources: West India Royal Commission, *Report*, London, 1897, Appendix B;
West Indian Sugar Commission, *Report*, London, 1930, continuation (Colonial No. 49, graphs opposite p. 82;
Statistical Abstract of the British Empire, 1924–1938.

GRENADA

Grenada is a rainy, volcanic island whose fertility rivals that of the East Indian spice islands. Its sheltered valleys are ideally suited for the cacao and nutmeg trees which today provide the principal exports. During the middle of the nineteenth century cacao was grown on the hillsides and sugar on the

valley floors. The fall of sugar prices led to the discovery that tree crops could flourish on the flatlands. Cacao production was expanded and nutmeg production was begun. These industries have so occupied the former sugar lands that today Grenada must import most of its sugar.

DOMINICA

Dominica, another rainy, volcanic island, is two-and-one-half times as large as Grenada. It has always produced a variety of crops including citrus fruits, coconuts, coffee, and vanilla. Until the decline of sugar prices, however, canes occupied much of the limited bottom lands. A local doctor suggested that limes be substituted for the unprofitable sugar. His advice was followed so completely that for several decades no sugar has been produced and citrus products have accounted for the bulk of the exports.

MONTSERRAT

Montserrat, although only one-tenth the size of Dominica, resembles it in many respects. Both islands are humid and volcanic, both have abandoned sugar, and both have specialized in limes and lime products.

The divergent economic histories of Dominica and Montserrat show the importance of small environmental differences. Montserrat is much more exposed to hurricanes than Dominica. This is important because hurricanes are especially destructive to tree crops which are only produced after an orchard has attained maturity. A hurricane in 1899 almost destroyed the lime orchards. These had just recovered from that hurricane when, in 1928, another hurricane destroyed them again.

Although Montserrat has not given up lime production, its planters have placed their emphasis on annual crops.

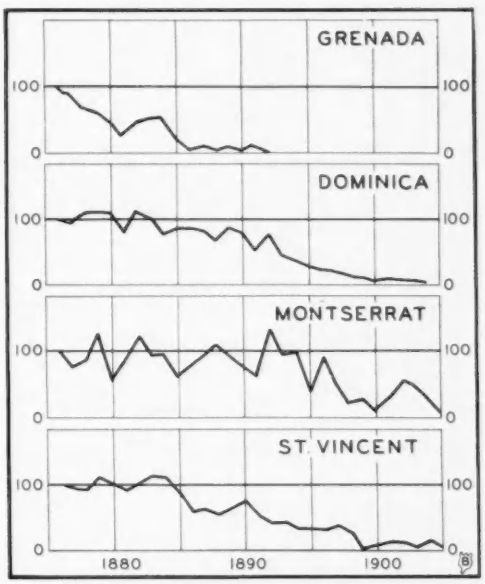


FIGURE 2.—Index numbers of the sugar export from those islands which later abandoned sugar. Tonnage exported in 1876 represents 100.

Another small environmental difference —the drier climate of Montserrat—has given them a wider choice of crops than Dominica. Thus it has been possible for them to cultivate Sea-island cotton which has produced as much as four-fifths of the exports. Onions and tomatoes are among the other crops which have replaced sugar and limes. Sugar is now among the imports.

ST. VINCENT

Although St. Vincent is a rainy, volcanic island slightly larger than Grenada, its crops differ markedly from those of its neighbor. St. Vincent's lowland soils are light and extremely porous. Hence there is little emphasis on crops requiring humid conditions; instead sugar was replaced by such crops as arrowroot, cotton, coconuts, cassava, and peanuts. Sugar cane is still raised in the broader coastal valleys and, in recent years, sugar products have ranked after arrowroot and cotton among the exports.

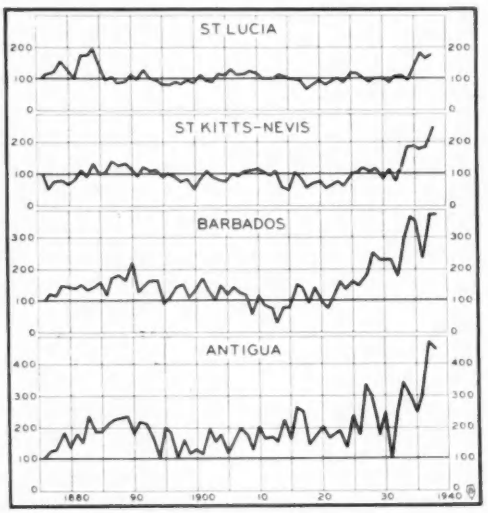


FIGURE 3.—Index numbers of the sugar exports from those islands which continually exported sugar. Tonnage exported in 1876 represents 100. Exports of molasses and syrup have been included in terms of the sugar equivalent.

ST. LUCIA

St. Lucia is an island of diversity. The rainfall varies from 35 inches along the leeward coast to 150 inches in the mountainous interior. Its surface includes both flat alluvial valleys and sharp volcanic peaks, some of which rise to over 3,000 feet. Consequently the island combines some of the economic characteristics of the flatter, drier sugar islands, such as Barbados, with those of the moist, rugged islands, such as Grenada. The exports now include cacao, bananas, lime oil, coconuts, and nutmegs, but the sugar products from the larger valleys are still the principal export.

THE SUGAR ISLANDS

St. Kitts-Nevis, Antigua, and Barbados are characterized by much level land, by low to moderate rainfall with frequent droughts, and by exposure to high winds. These conditions have discouraged or prohibited the growth of limes, cacao, bananas, nutmegs, and other crops which have replaced sugar elsewhere. The most successful alternative crop has been Sea-island cotton. Unfortunately the market for this product has been so limited, and the danger from pests, such as the pink bollworm, has been so great, that cotton could not be used to replace sugar completely. Cotton is still produced on each of these islands but its value is usually but a fraction of the value of the sugar produced.

Thus the planters in St. Kitts, Antigua, and Barbados were forced to increase the efficiency of their sugar industry because they had no satisfactory alternative industry. The planters might have emigrated, in fact some did, but most of them had their fortune invested in these islands and were reluctant to leave the Antilles to start life afresh in Canada or England. Environmental necessity was here the mother of invention, and technical and economic miracles resulted.

In St. Kitts and Antigua, the small, inefficient windmills were discarded, and a large central factory was erected on each island. Better varieties of canes were introduced, better methods of fertilization were adopted, and pest- and disease-control measures were instituted. As is indicated on Figure 3, these improvements were introduced first in Antigua, later in St. Kitts. (The small island of Nevis, usually included with St. Kitts, has not been able to install a modern sugar factory. Consequently, its sugar has been largely displaced by cotton and ground provisions.) In 1929, the West Indian Sugar Commission reported that these islands produced sugar more cheaply than any of the other British West Indies, not even excluding Jamaica and Trinidad.

In densely-populated Barbados, improvements were not so easily made as in St. Kitts and Antigua. (For a detailed account of the struggle to

increase sugar production in Barbados, see O. P. Starkey, *The Economic Geography of Barbados*, Columbia University Press, 1939.) Although steam factories replaced many of the Barbadian windmills, the surface, often cut up by canyon-like gullies, made it almost impossible to bring the canes to one central factory for grinding. Furthermore, the numerous agricultural laborers in need of employment made it inadvisable to introduce much labor-saving machinery. But the need for increased production was so great that, despite these handicaps, Barbados led the other islands in developing better methods. ("What everyone should realize is that Barbados with its comparatively small rainfall, large population and small area must have increased sucrose in the cane and there is no other sugar research station in the world which is working on this problem. . . . we must either produce sweeter and heavier canes for all parts of the island and all periods of the crop or go out of sugar cultivation altogether."—*Report on the Department of Science and Agriculture*, 1930–31, Barbados, 1931, p. 11.) In fact, the planters and scientists working in Barbados were largely responsible for the new cane varieties, new methods of fertilization, and new pest-control measures which, when introduced in Antigua and St. Kitts, so greatly increased sugar yields in those islands.

Barbadian technological progress is reflected in Barbadian production figures, since the acreage in canes has remained almost unchanged. In the 1870's, the annual sugar output averaged about 40,000 tons. More intensive cultivation and better manuring increased the production to over 60,000 tons in the late 1880's. Pests and cane diseases lowered the sugar production after 1890 but the tonnage produced still exceeded that in the 1870's.

During this period of reduced production, Barbadians experimented with cotton, tomatoes, bananas, and other crops. Much more important, however, were the experiments carried out by a few scientists and planters during the same period. Seedlings, such as B 726, Ba 11569, and B.H. 10(12), were developed which yielded twice as much cane per acre as the White Transparent canes used in the 1890's. Some of the new varieties proved to be disease- and pest-resistant, a fact which helped maintain the yields. More exact methods of fertilization, mulching, and spacing were worked out. Insect collection and spraying campaigns were instituted. Finally the system of manufacture was completely revised so that the yield of sugar which had been 7.34 tons per 100 tons of cane in 1884 was increased to 11.8 tons in 1938. As a consequence of these improvements the Barbadian output in recent years has reached nearly four times that in the 1870's (Figures 3 and 4).

WILL SUGAR COME BACK IN THE OTHER ISLANDS?

The soils and climates of Grenada, St. Vincent, Dominica, and Montserrat are as good for sugar production, or better than those in the sugar islands. Will the islands take advantage of new methods to return to sugar cultivation? Probably they will not, in fact only one, St. Vincent, has attempted to revive its sugar industry and that revival has been only on a moderate scale.

There are three important reasons for the failure of Grenada, Dominica, and Montserrat to reëstablish their sugar industries. First, the future of sugar prices is uncertain, hence capital investments in new sugar factories are considered poor risks. Second, the level lands in the islands are distributed among many narrow valleys, each of

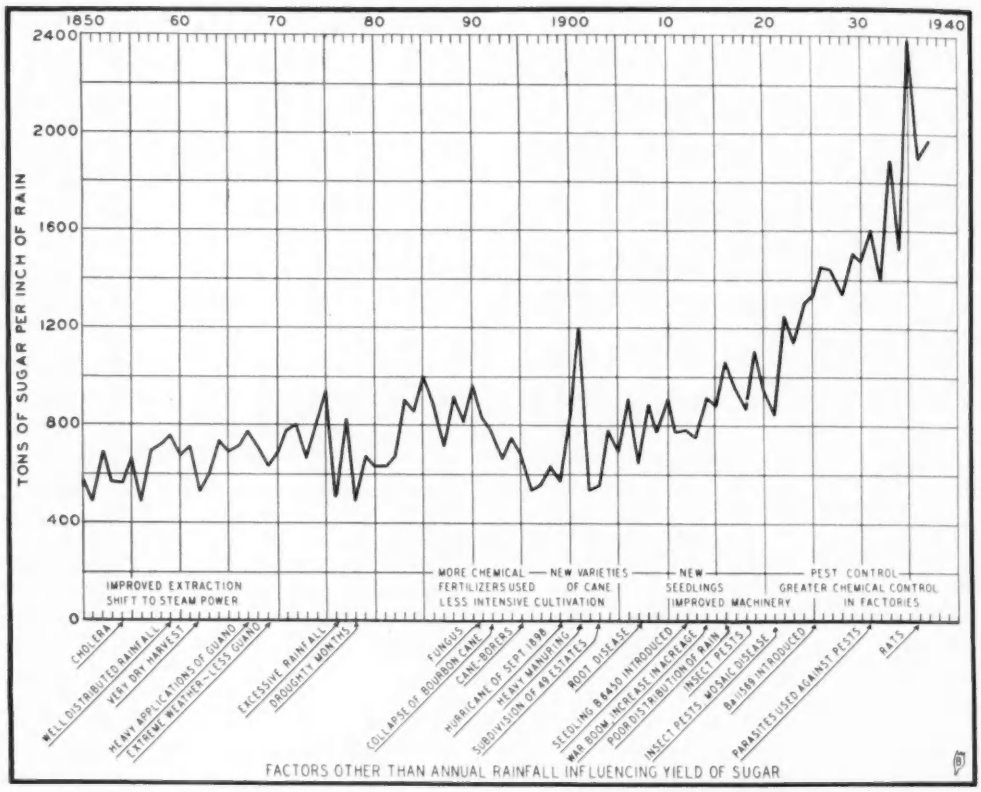


FIGURE 4.—The amount of sugar produced in Barbados for each inch of rainfall during the calendar year preceding the harvest.

which would have difficulty in producing enough cane to supply a modern factory. Finally, the islands are fairly well satisfied with the crops they substituted for sugar cane.

SUGAR PRICES AND PEASANT AGRICULTURE

Throughout the Lesser Antilles, declining prices have forced many of the less fertile sugar estates into bankruptcy. Usually these estates have been subdivided and sold in small lots to a growing Negro peasantry. The resulting peasant agriculture has become most common and most successful on those islands which have abandoned sugar. There the usual peasant crops have been ground provisions, cotton, limes, and cacao. But, on the sugar islands, the peasants, on farms too small for efficient sugar production, have tried to ape the planters by raising canes.

CONCLUSIONS

The decline of sugar prices since 1872 has caused: (1) the adoption of alternative crops where possible and profitable; (2) an increasing efficiency in sugar production where alternative crops were not feasible; and (3) the subdivision of the inefficient estates among a Negro peasantry. Thus, the fall in prices, although disastrous to many of the planters, has initiated changes which, in the long run, will probably prove beneficial to the economies of the Lesser Antilles.

BOOK REVIEWS

PEATTIE, RODERICK. *The Incurable Romantic.* Published by the Macmillan Company, New York, 1941. $3.00.

This is an informal and highly personal story of Roderick Peattie and the Peattie family, both past and present. The author's love for adventure and romanticism began early in life. Now he and his family live (and write) with similar lack of convention.

Mr. Peattie, in a simple yet stimulating style, tells of his experiences as student, soldier, professor, and enthusiastic mountain climber. He describes the youthful romance with his wife, who has shared his travels and, in some cases, continued them beyond the vagrancies of her husband. The tale of his experiences at the front during the first World War, are colorful and interesting. He lived among the mountain communities of Europe in a manner that causes us non-travellers to wonder if we aren't missing the most important part of life. His rebuilt Vermont farm homestead, and the stories that have resulted from it are further proof that the soundest way to learn the philosophy and gain understanding of a region is to live there and associate with the local folk.

However, only part of Dr. Peattie's abundant energy has been spent on the byways of the world. His impressions of the Universities of Chicago, Harvard, Williams, and Ohio State, along with some evaluation of his teachers and colleagues reveal a different side of his life. Professor Peattie is a human geographer. He has never lost contact with young people and their ideas. If such a loss had impended his children would not have permitted his doing so. They are typical Peatties in every sense.

Finally, the author is an energetic and enthusiastic teacher. Popular? Certainly. He teaches as he writes, simply and informally. His lectures are punctuated with colorful, personal illustrations from his varied travels and studies. His former students will not be surprised to find in this book many paragraphs they have heard in the classroom, the office on the top floor of the Commerce Building, or the home on Perry Street. They will be pleased to see them in print. Regardless of place, the Peattie personality (frankness, humor, and enthusiastic enjoyment of life) is cheerful and encouraging.

The book should be read by every college teacher, by undergraduate students, and all others who wish to get more enjoyment from living on this earth for it contains many stimulating, thought-provoking statements. (Some of its dogmatic declarations should not be taken too literally.) It suggests that it "is fun to be a geographer" and proves that travel and homemaking in any place is both an interesting and a valuable experience.

ALDEN CUTSHALL

KEESING, FELIX M. *The South Seas in the Modern World.* The John Day Company, New York, 1941. Maps, Appendices, and Bibliography. 391 pp. $3.50. Published under the auspices of the Secretariat, Institute of Pacific Relations, and the University of Hawaii.

Dr. Keesing, being an anthropologist, naturally approaches geographical analysis from that viewpoint. His problem is complicated by vastness of area and heterogeneity of environmental, cultural, and political factors in the region about which he writes. Native systems of life differ widely. Imperialism with its competition between powers and its diversity of policy is superimposed upon the indigenous social and economic structure.

Cultural change in the islands has come from trial-and-error experimentation. By contact with modern civilization traditional values and patterns of behavior toppled. Some native groups and individuals have been able to work out new patterns which have yielded them a reasonable stability. However, the characteristic features of the new period have been confusion and movement and, where the alien has arbitrarily governed, frustration and resentment.

In the economic field, large scale exploitation of minerals and a few specialized agricultural products is replacing small white holders for whom brown, black, and yellow-skinned laborers skimmed the cream of early resources. New needs and ambitions derived from contact with traders are stimulating the peoples to enter more fully into commercial economy and foreign trade.

Strategic importance of the area has been marked in recent years by tightening of imperial bonds, renewed colonial claims of Germany, Japan's expansionist policies, and the violation of naval and non-fortification agreements. Islands of military and naval importance have been intensively fortified and prepared long in advance for the expected Pacific war. Japan declared that the South Seas or Nanyo were to be considered a vital sphere of Japanese interest and a part of Greater East Asia. The United States adopted a more positive attitude in the area, fortifying and improving its possessions at strategic points.

The native islanders evinced keen interest in the preparations even though civilized people who made them give up their feuding and fight-

ing were turning their homes into a potential battleground. As part of their modern experiences the peoples have been imbued with loyalty to the imperial unit to which they belong, and have respect for its symbols. Especially in times of crisis do such feelings become intensified with messages of loyalty from chiefs, donations from tribes, and enlistments into the army by individuals. Such factors must be taken into account in future adjustments. The people are not mere ciphers to be moved about on political whims but human beings with opinions and, in many cases, well developed loyalties.

Current events effectively obscure the future of the islands. Under totalitarian control the islands could be imagined areas of intensive production where, under governmental control and management, busy factories would supply up to the maximum their resources permit. In contrast, under another policy, white settlers might withdraw almost completely and the people, reverting to peasantry, meet limited commercial needs by preparing traditional shell and copra for world markets but holding primarily to a subsistence basis of livelihood. However, the people have gone too far in assimilating non-native elements which they find useful or interesting to revert easily to their native state without disruption of social and economic life. It seems certain that there will be a change in future administration policies from the exploitation of the past which will compensate the native to greater degree.

Dr. Keesing's analysis is not, strictly speaking, geographic for he omits the climatic, physiographic, pedologic, and other physical factors which geographers consider important. The vastness of the area and diversity of environment have compelled him to concentrate on his specialty and even there he has of necessity written in generalities. In spite of such limitations he has done a good job on a basic geographic factor which we geographers often neglect in our analyses of geographic regions.

The simplified maps give a clearer picture of a complex region than do more common maps which show every pinpoint of land. The bibliography is detailed and presents not only general references but also sources of material on each of the island groups and even for specific islands which have been explored and studied. Appendices, plus bibliography, which include almost one-quarter of the volume, which present in condensed form material discussed more fully in the body of the book are of special value in their elaboration of economic and trade relationships.

JOHN W. REITH